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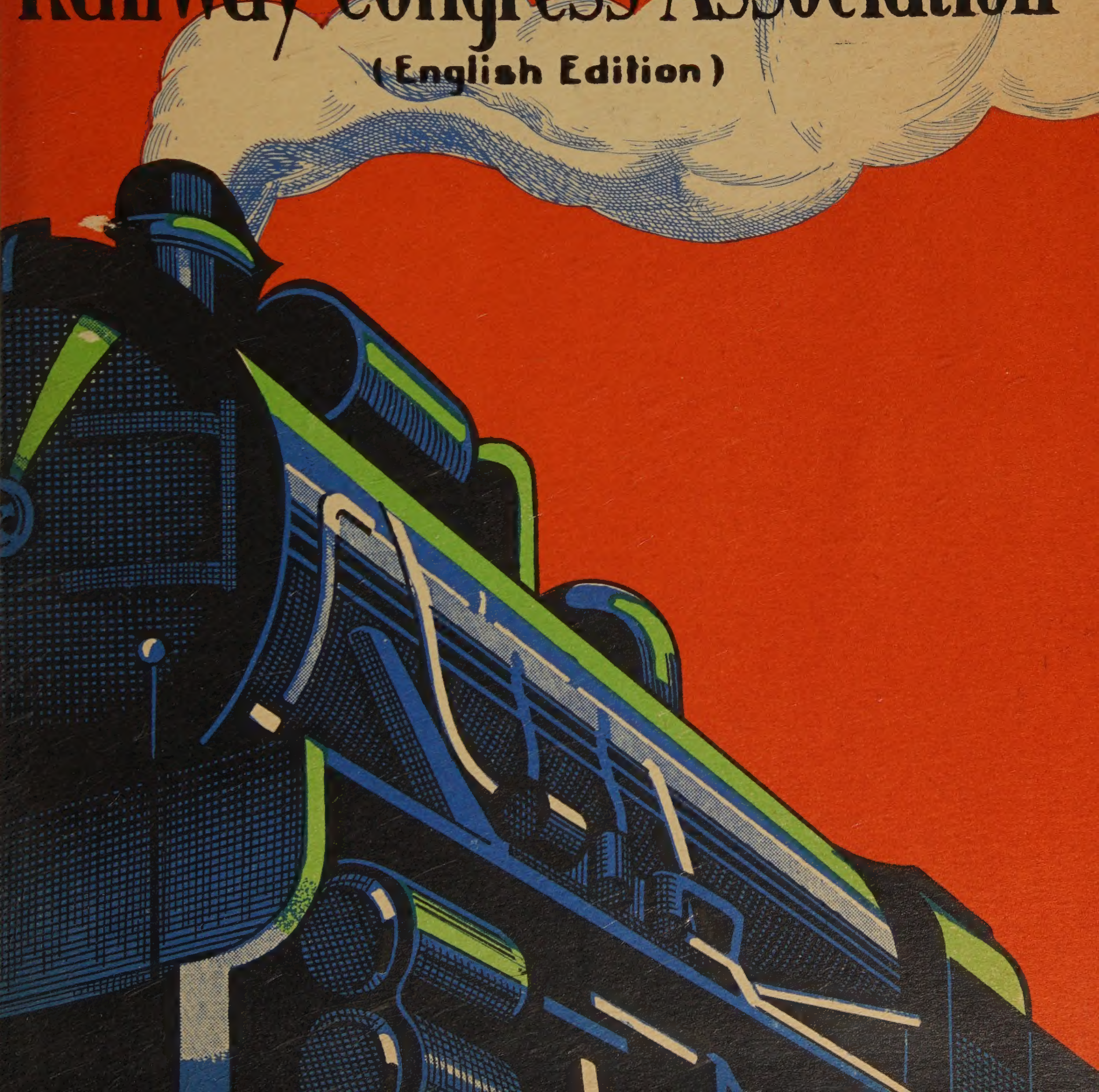
(English Edition)



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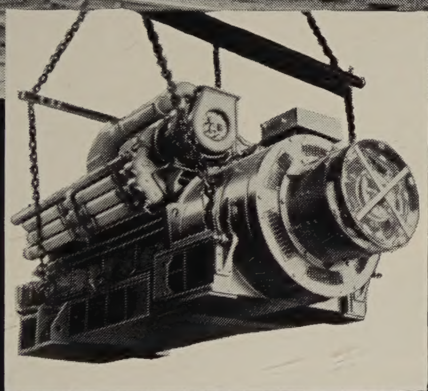

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OF THE

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(ENGLISH EDITION)

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .144 .4 (485)]

How long welded rails are laid in Sweden in conjunction with new tracks,

by Tord FOGELBERG,
Civil Div. Engineer, Swedish State Railways.

The Swedish State Railways, in keeping with many other railways, have realised the great advantages of long welded rails and, for some years now, on a conventional track with joints. In Sweden, the annual temperature variations may be as high as 90° C. and the daily variation up to 25° C.

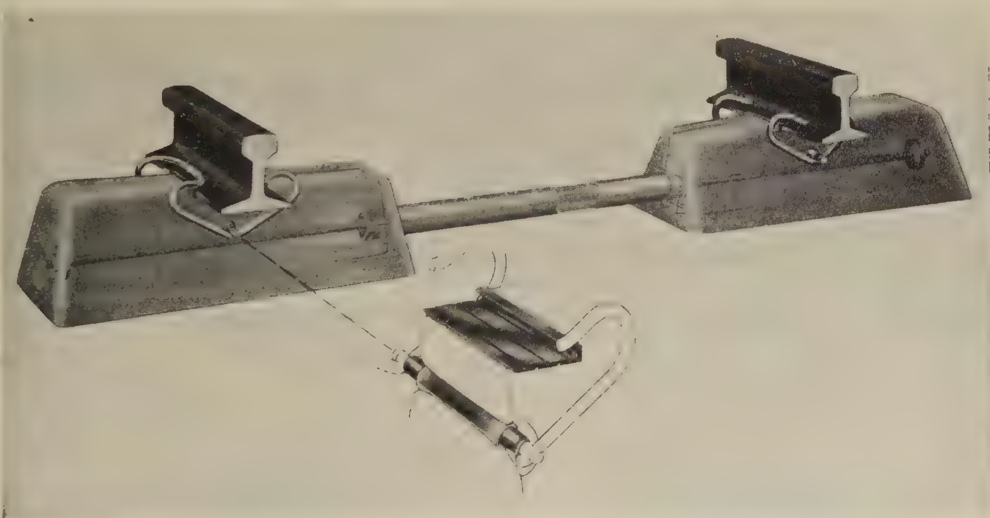
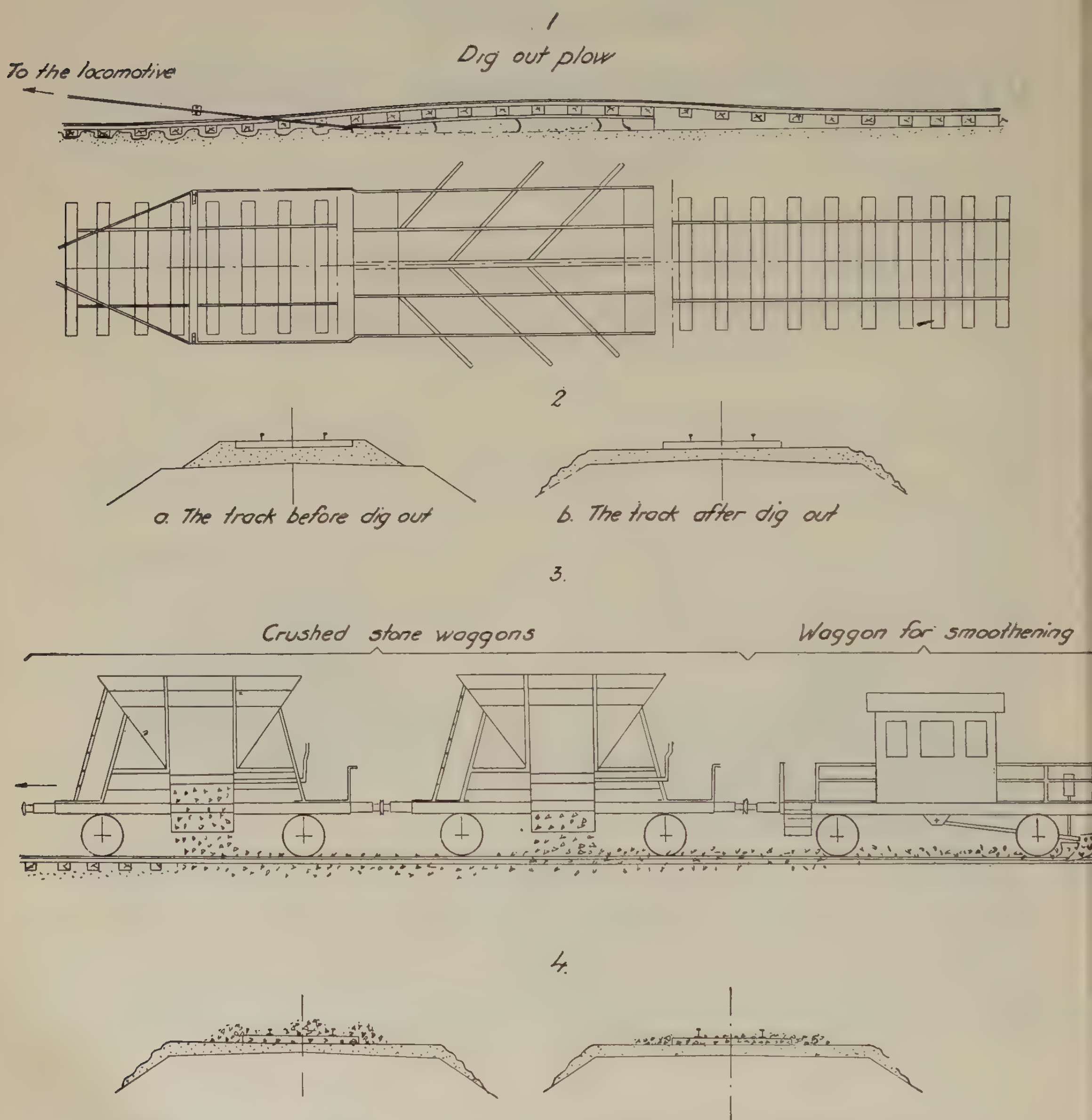


Fig. 1.

have made increased use of this construction on main line tracks.

However, in order to withstand the great stresses resulting from temperature variations, long welded rails must be entirely different in design to those used

In order to prevent the rails from moving and to avoid the need of inserting a large number of rail anchors it is first of all essential to pay great atten- track be heavy. Despite the fact that tion to the rail fastenings. Secondly, to



a) Crushed stone for the raise.

b) After smoothening.

Compare fig. 3.

Fig. 2. — Reballasting

prevent warping, it is important that the Sweden is rich in timber it has been considered that concrete sleepers offer many advantages in this connection.

In an earlier article on the same subject (*Bulletin of the International Railways Congress*, Nov. 1957, p. 845) the writer described the Swedish 101 con-

crete sleeper and the « Fist » rail fastening and, for this reason, only a brief report will be given here.

In many cases, the sub-grade in Sweden is such that it is dificult to obtain a stable track. In addition to the fact

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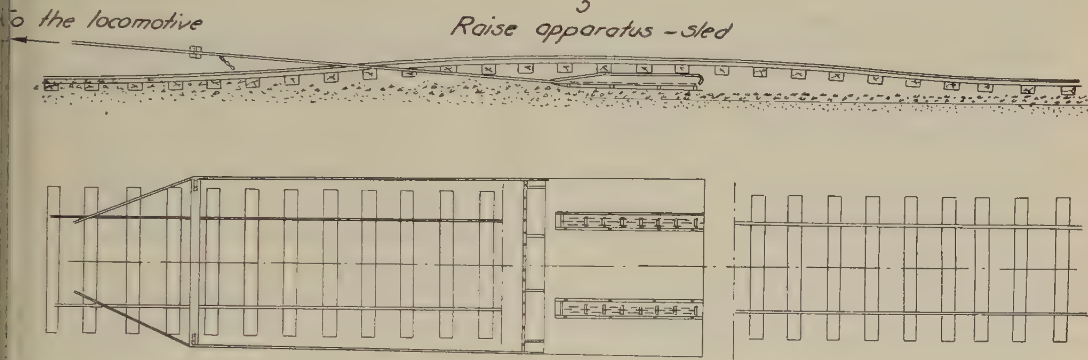

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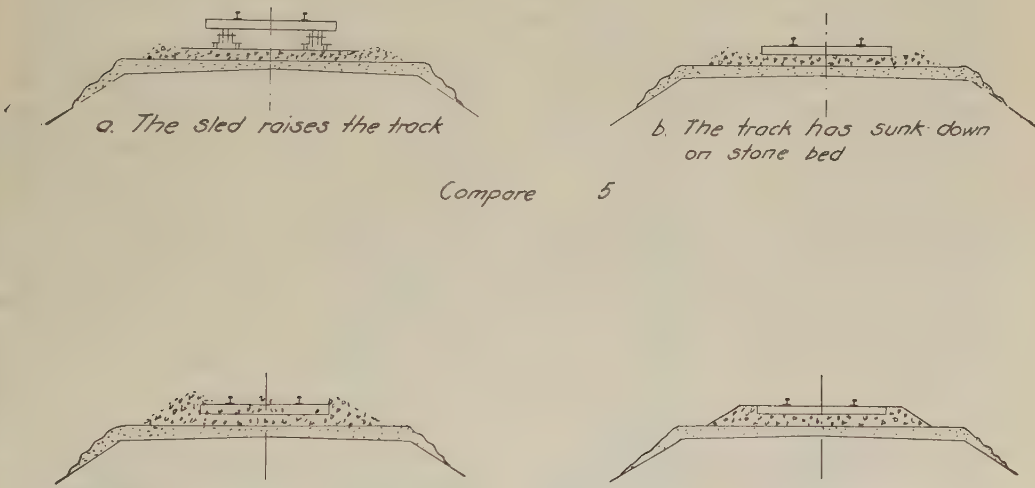


c) Additional stone brought on between rails at sides.

d) The stone bed smoothened and the track ready for final adjustment.

en, system Fogelberg.

that mossy and clay soils occur very frequently — and that the ground is consequently subject to slow setting — we have the problem of frost-heaves in the winter and these cause a lot of trouble along the track when the spring thaw comes.

Under such circumstances, and since the track must to some extent be capable of adjusting itself to « shifting » sub-grades, the Swedish State Railways decided that the sleeper and rail fastenings must be elastic. An elactic track is also better able to resist vibration from

passing trains than a rigid track. As regards the technical construction of a concrete sleeper, pre-stressed concrete has great advantages over ordinary reinforced concrete. Other conditions being the same, it is generally possible to use a reduced weight of iron with pre-stressed concrete. However, the great advantage of pre-stressed concrete is that any cracks arising are always closed, once the sleeper is unloaded, and consequently less serious than is the case with ordinary reinforced concrete where the cracks remain open. As a result, it may be expected that a pre-stressed concrete sleeper will have a longer life.

The Swedish 101 concrete sleeper, as will be seen in figure 1, consists of two concrete blocks joined together by means of a concrete-filled steel tube penetrating 5 cm into each block. The concrete blocks are reinforced with a pre-stressed bar of spring steel passing through the steel tube and anchored at the ends with nuts and washers. The pre-stress force, which thus acts on the whole sleeper, is 13.5 metric tons.

The 63 $\times$ 3 mm steel tube has a yield strength of 53 kg/mm² and is galvanized to increase the resistance to corrosion. The tube is subject to permanent pressure and this too is of advantage from the point of view of corrosion.

The ends of the tube have milled slots which ensure torsional rigidity. To further ensure the union between the tube ends and the concrete ordinary 3 mm bar reinforcement has been laid in this part of the blocks.

The pre-stressed central tube results in the sleeper having very good elasticity properties, and the concrete blocks have every opportunity of following the changes in the ballast bed without becoming deformed. In other words, the sleeper is similar to a strong spring which is unaltered at rest but which offers a strong, but soft, resistance under load.

As mentioned earlier, the use of long welded rails means that great attention must be paid to the rail fastening. A double elastic fastening is decidedly superior to a single, a fact upon which most experts agree. However, a rail fastening must, in addition to preferably holding the rail, prevent rail creep without special anchorages, be capable of providing an elastic bond between the rail and the sleeper and also be simple in design, have few component parts and, finally, be relatively inexpensive. If possible, it should be applied in such a way as to cause moments which are not added to the moments caused by the wheel loads.

The Fist rail fastening meets these requirements and the Swedish State Railways have therefore decided to use this type of fastening on tracks formed from long welded rails. As will be seen from figure 1, the fastening consists of a stirrup of 15-mm spring steel. The stirrup is bent so as to present three points of contact to the rail and to press the rail down onto the sleeper with a force of about 2 000 kg. The stirrup is fitted to the sleeper with an 18-mm spring steel pin, each end of which is crooked to prevent movement due to vibrations from the trains. The pin is inserted in a horizontal hole directly under the rail foot. The hole has a conical tube at each end to equalize the pressure from the pin. The clamping force produced by the fastening is applied centrally under hte rail foot and results in mo-

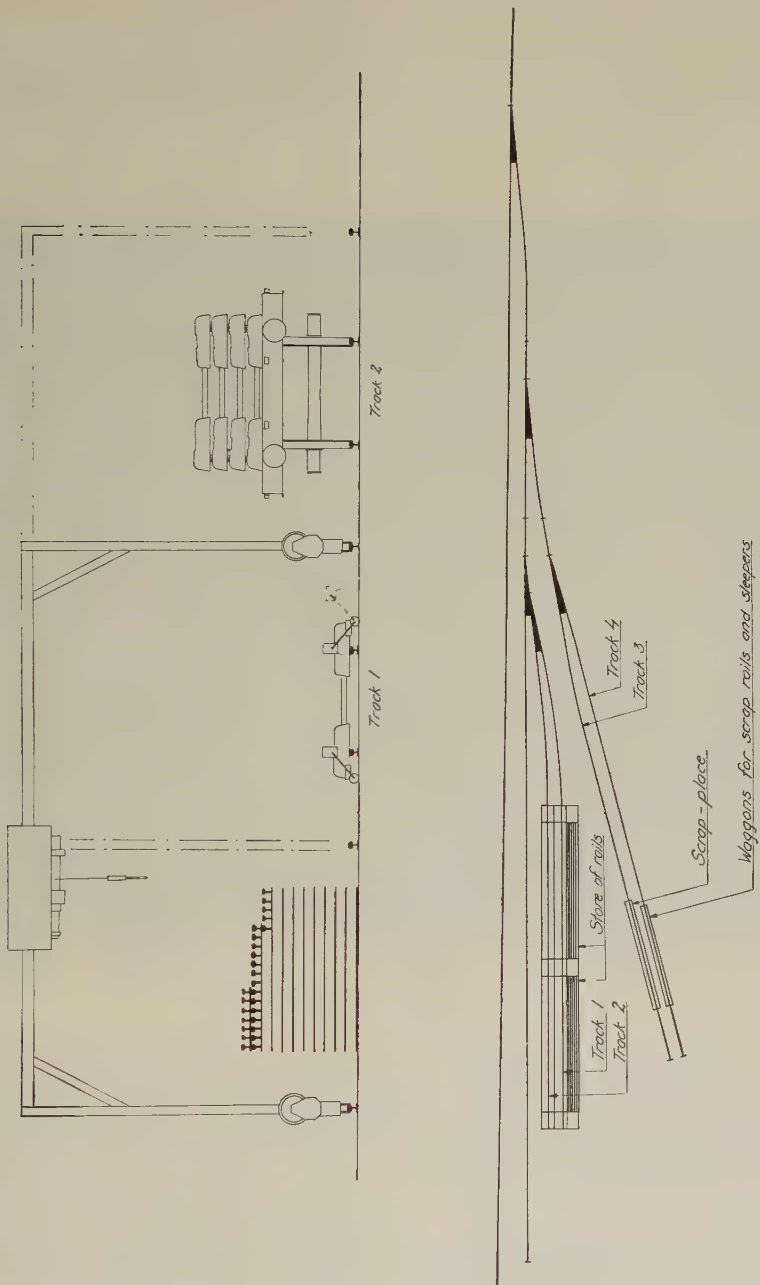

Track 2
Track 1
Track 4
Track 3
Scrap-place
Waggons for scrap rails and sleepers
Store of rails
Track 1
Track 2

Fig. 3.

ments and stresses which are opposite in direction and force to those resulting from the wheel loads on the rails.

The rail is supported by a fluted rubber pad fitted into a slot on the top of the sleeper. The rubber pad is provided with up-turned, curved lips which slip over the sides of the rail foot. The rubber pad acts as a shock absorber and effectively damps the lateral vibrations transmitted from the rail to the sleeper.

The sides of the rubber pad also form an effective insulation between the rail foot and the sleeper. To satisfy the requirements of signal engineers the pin is adequately insulated with a 2.5 mm textile-reinforced jacket of phenol plastic. Tests have indicated that, other conditions being equal, the conductor resistance on a track employing concrete sleepers and Fist rail fastenings is decidedly greater than is the case with ordinary wooden sleeper tracks.

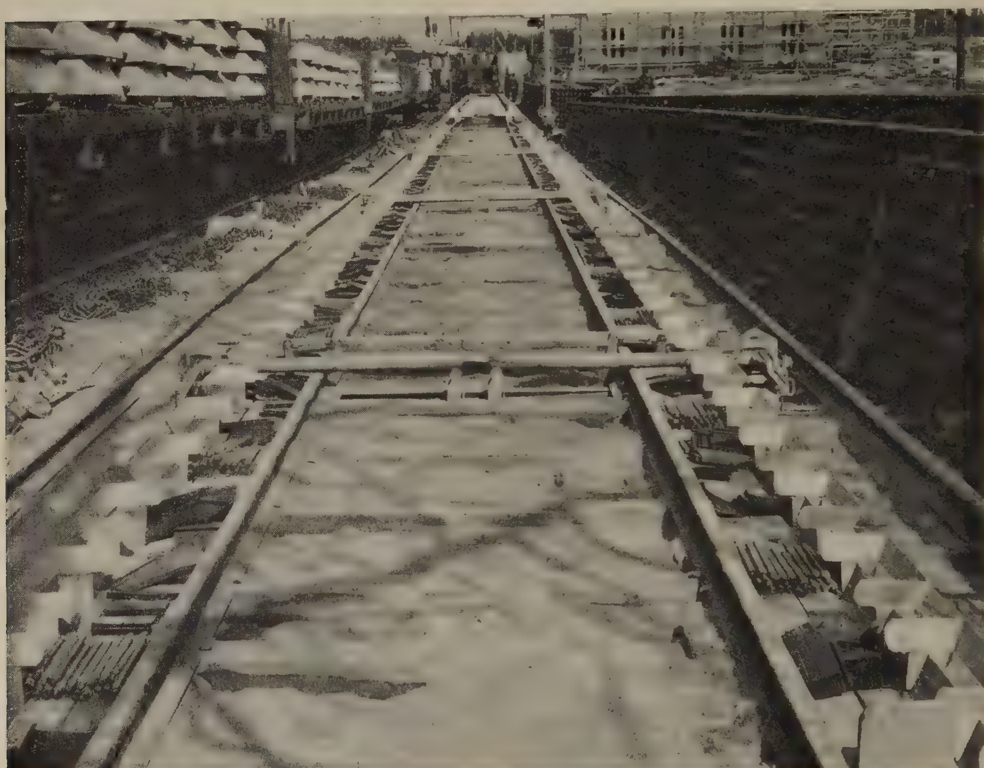


Fig. 4.

Having given you this brief description of the equipment I should now like to say something about the method of laying long welded rails as practiced in

Sweden. The procedure has been worked out by the Swedish State Railways as being the best method when replacing wooden sleepers with concrete sleepers and long welded rails.

In Sweden, the cost of a thermit welded joint made on the site is about twice as much as that for a flash butt-welded joint carried out in a workshop. This would seem to suggest that it would be cheaper to weld the rails in long lengths in the workshop and transport them to the track. However, when tackling a job of the size and complexity of exchanging a complete track, consideration must also be paid to certain other factors when seeking to keep costs to a minimum. The main theme has been to concentrate as much of the work as possible to a station yard. This enables the work to be rationalized and controlled to a greater extent than would be possible on the line. It also means that the work is not interrupted by passing trains.

Fig. 5.

The sequence of work can, in principle, be divided into the following main groups :

1) preliminary work on the old track;

2) building the pre-fabricated track (panels in a framing plant in the yard);

3) transporting the panels to the track;

4) fitting the new panels and removing the old track sections;

Fig. 6.

5) transporting the old track sections to the yard;

6) stripping and sorting the old track sections and stacking the parts;

7) making the necessary adjustments, etc., on the track.

The preliminary work consists of clearing the old track so that the ballast is removed from between the sleepers. A track plough placed under the track and drawn by a locomotive is used for this purpose.

If the new track is to have the same elevation as the old one a track plough is used. This has four inclined blades which successively shift the ballast from between the sleepers and to the side of the track as the locomotive pulls the plough forward.

If the track is to be raised, on the other hand, we use the sled. This functions like a surf board. As the sled is pulled forward the track is lifted and the ballast between the sleepers falls down

in front of the sled and is evened out. After the sled has passed the track sinks onto the smooth ballast surface which has now been raised to a height corresponding to the amount of ballast added. at the same time. Figure 2 shows the method in principle. Immediately behind the plough or sled comes a gang of six men who prise the track into position. This is quite easy since, with a little

Fig. 7.

This method has been used in Sweden since 1949, and since that date in Canada and the U.S.A. under the name of the Mannix plough and sled.

The adoption of this method results in a great saving of time since it is possible to clear about 1 km of track in 1 h and, if needs be, raise the track practice, the gang can do this immediately before the track « touches down » behind the plough or sled. We now have a good basis for the removal of the old track before laying the new one with concrete sleepers and long welded rails.

But, this must first of all be constructed. This is done at a special

« panel factory » in a nearby yard. The principal details are shown in figure 3. It is sometimes necessary to make certain modifications to suit local conditions. On the site shown in figure 4, we can build two 40-m panels simultaneously. Four men work on each panel. It is also possible to build 80-m panels.

Before the actual construction work begins the 40-m rails are unloaded from track 1 to point 2. For this purpose we use two electric overhead cranes which run on special rails crossing

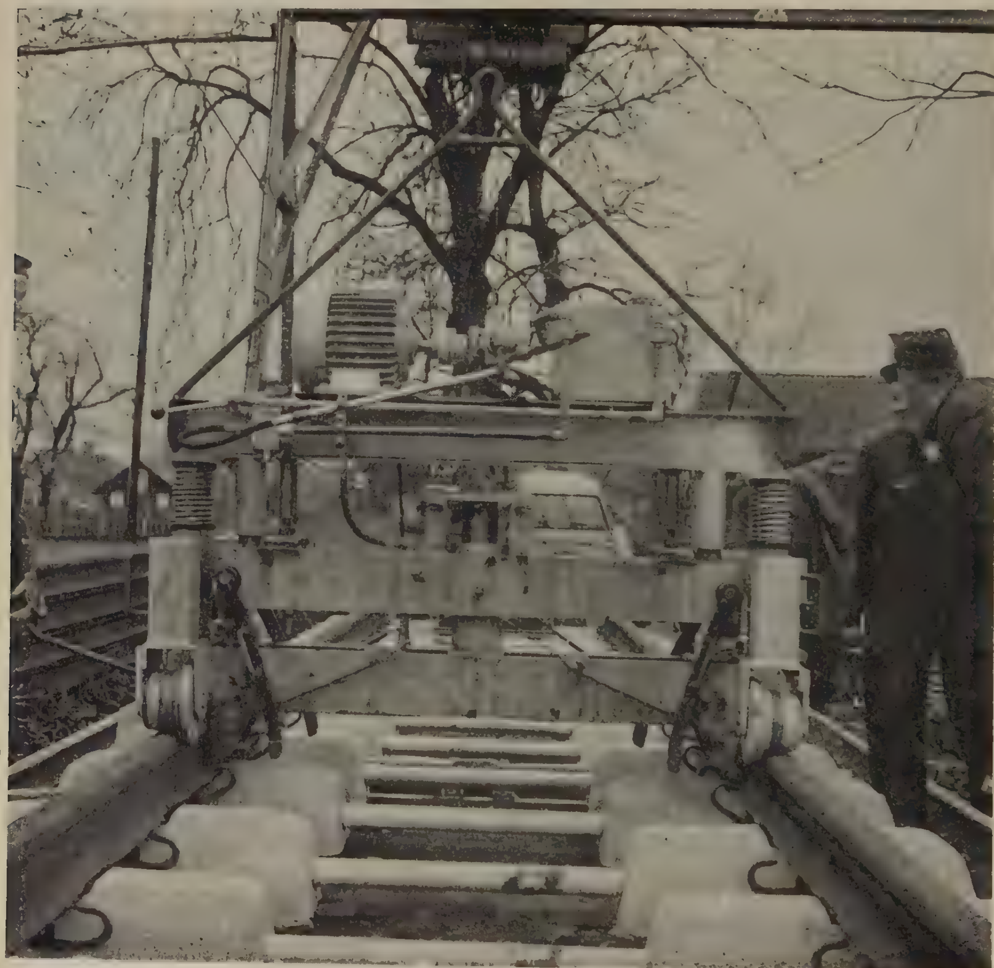


Fig. 8.

track 1 and point 2. During the period of construction track 1 is used as the assembly point for the concrete sleeper panel.

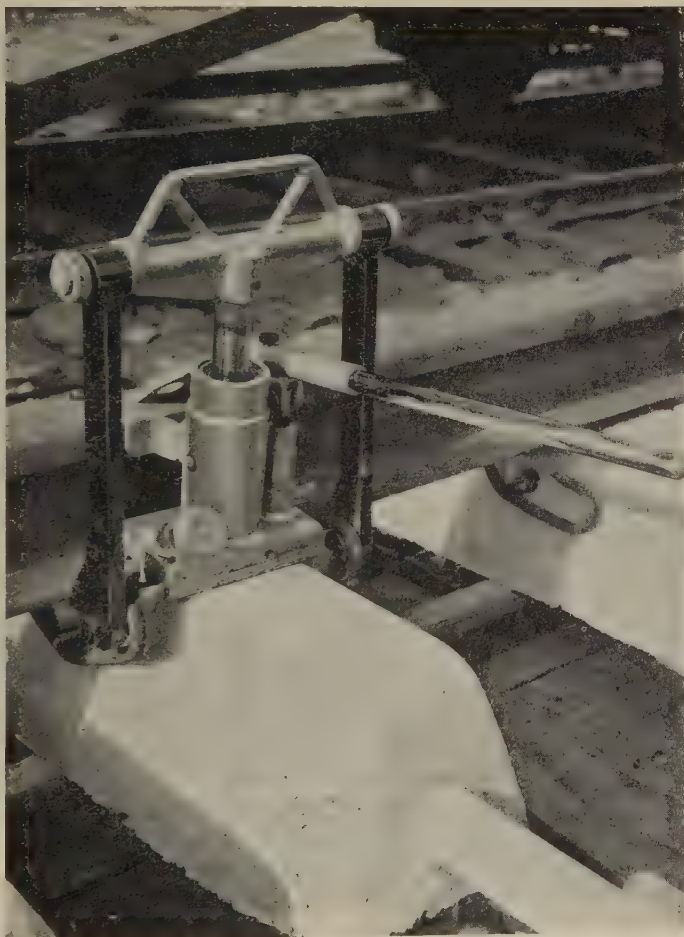


Fig. 9.

In order to permit this work to be carried out rationally and accurately, track 1 is fitted with certain special devices, i.e., on the track by the outside of the rail, are fixed jigs onto which the sleepers are placed at the correct distance and spacing.

The concrete sleepers are delivered from the concrete factory to track 2 in ordinary goods waggons. They are unloaded 4 at a time with the aid of the crane which, for this operation, is

moved laterally to the second rail so that it is above the waggons and the laying site (track 1).

With the aid of a special device (fig. 5) the sleepers can be unloaded from the waggons at the same time as they are spaced out at the correct distance and placed in the jigs at the place of work. The rubber pads and the pins and stirrups for the Fist rail fastening are placed at the sleeper ends in advance. The cranes are now moved laterally so that they can operate over the construction point and the stack of rails. The 40-m long rails are lifted with the aid of these cranes and a special sling and moved down to the laying site (fig. 6). The rails are placed on special vertically adjustable bars a little above the recess in the sleeper. The longitudinal position of the rail is adjusted with the aid of a movable arm (fig. 7). The rubber pads are placed in position around the rail foot and the bars are

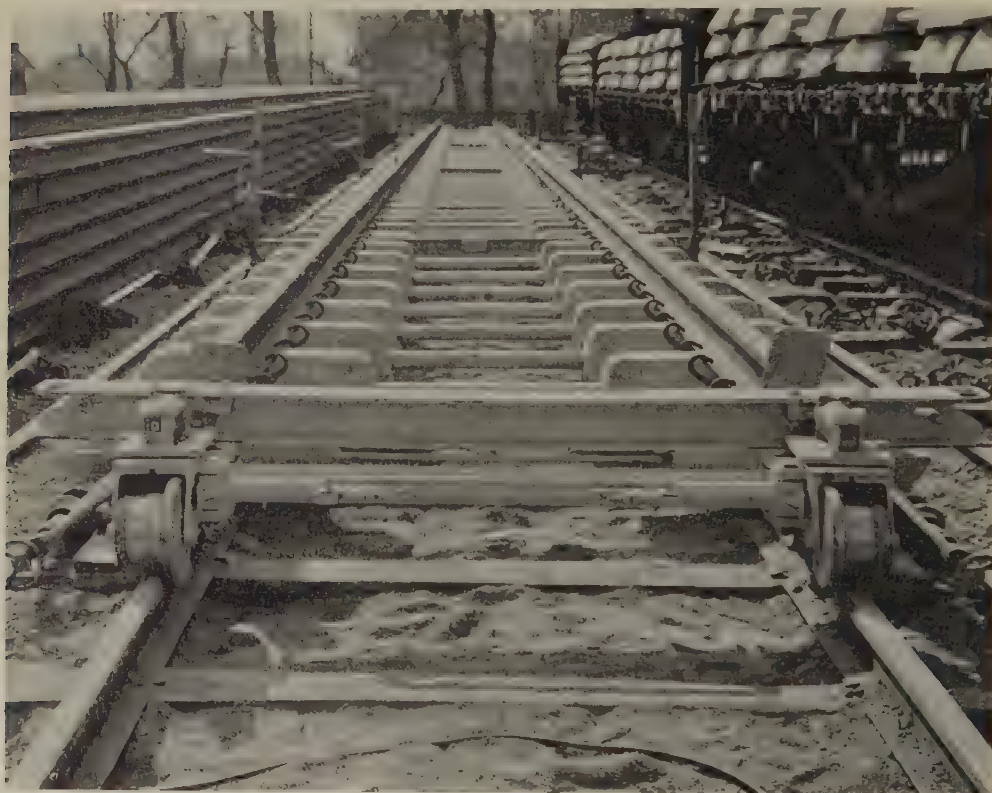


Fig. 10.

then lowered so that the rail slips into the recess in the sleeper.

The Fist rail fastenings can now be fitted. All the stirrups are placed at the end of the sleepers with the free ends pointing towards the track. The stirrup is inserted under the rail and the insulating pin is inserted into the hole. With the aid of a special hydraulic apparatus (fig. 8) the stirrup is pressed forwards, upwards and inwards under and over the rail foot. At the same time the relative positions of the rails are held constant so as to avoid any disturbance of the track gauge.

Fig. 11.

It is also possible to use a simpler form of hydraulic tool (fig. 9) to assemble the rail fastenings. However, in this case a special gauge keeper must be used.

After the panels have been prepared they are loaded onto trolleys — four trolleys under each panel. Loading is (fig. 10) are so constructed that the panel more or less keeps its shape when rounding curves and passing over points.

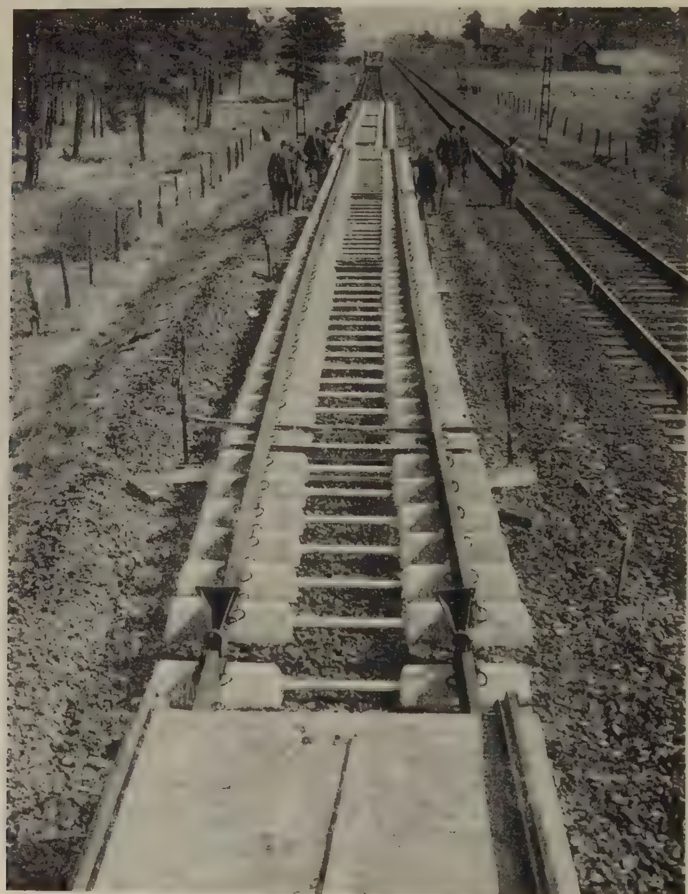


Fig. 12.

done with ordinary jacks placed under the ends of the sleepers. The jacks work in pairs and are joined by a girder placed under the rail foot between the sleepers.

The trolleys are pushed in under the panel from the end. The trolleys The panel is placed on a beam but supported by two rollers on the trolleys so that the panel is not greatly affected by the movement of the trolleys on the corners. This arrangement enables the panel to move laterally in either direction through a distance of 35 cm.

The complete panel — as a rule two 40-m units making up 80-m of track — is pushed from behind by a prime mover to the place of work ready for assembly.

Replacing the old track section with the new one can be done in two ways. The method chosen depends on the time available.

If the line is available all day — as is often the case on double tracks — a trackless gap awaits the arrival of the new section. In this gap so-called helper rails, that is rails with a special profile (see fig. 11), have been laid direct on the ballast. This auxiliary track is joined to the old track by means of an « aid track ».

Fig. 13.

The new panel is pushed down over the aid-track and out along the helper rail until it comes into position against the previously inserted panel. The new panel is now lifted (see fig. 12) from the trolleys with the aid of ordinary jacks (similar to those used on the construction site).

The corresponding length of old track is now lifted up from the ballast bed in the same way. The aid-track is taken away and the helper-rails and the trolleys pulled by the prime mover so that they to the spot where the next new panel is to be laid. The newly laid panels are welded together into 360-m lengths by thermit welding. The necessary additional ballast is added and the track is

Fig. 14.

come under the raised panel (old track) (fig. 13). The latter is laid on the trolleys. The aid-track is moved forwards and the old panel can be carted away.

The new concrete sleeper panel can now be lowered onto the ballast bed (fig. 14) and the jacks moved forward

levelled and adjusted. After the track has been in use for some time the 360-m panels are welded together. Joints are only left for the necessary insulation of the rail conductors (when necessary).

If the track is only available for a short time, and it is consequently im-

possible to have a trackless gap, the method must be varied somewhat. It is then necessary to use a larger number of trolleys. While the new concrete sleeper panels are being carried to the site loaded onto trolleys. The old panels can now be pushed up onto the new track and the new panels placed in the correct position. The concrete sleeper panel is raised, the trolleys and the hel-

Fig. 15.

the old section of track is lifted and placed on trolleys. Two pairs of « aid-tracks » are laid — one pair at the joint between the old track and the helper-rail and one pair at the join between the new track and the helper-rail. When the new panels arrive they are joined to the old panels, which latter are now per-rails are removed and, after these panels have been lowered, the prime mover pulls the old panels away.

As a rule a small gap arises between the old and new track sections. This gap is filled in with a section of old rail to allow the trains to pass.

When using this second method one

should, if possible, operate with a larger number of panels, e.g., four 40-m panels or 160 m of track, to achieve the greatest effect.

When the old rails arrive at the scrapyard — which is generally located close to the assembly site — they are moved into a special track (track 3 in fig. 3). Using a chain conveyor the panels are fed into a hydraulic press (fig. 15). The press tears the rails from the sleeper and the fastenings and nails are placed in special boxes. The old sleepers drop onto a rubber conveyor belt after being sorted into usable and scrap sleepers and are loaded onto waggons (fig. 16). The old rails are loaded onto waggons with the aid of a crane.

Fig. 16.

The working method described — which has now been employed for almost two seasons — has proved very effective and is a great saver of time. Except for welding and ballast work, the following labour has been employed :

1 foreman;
$2 \times 4 = 8$ workers, on the building site for loading the panels and unloading the material;
4 workers, in the scrapyard.
8 workers, on the line for receiving the new panels and removing the old;
4 workers, for transporting the panels and switching;
Total 1 foreman and 24 men.

As a rule, it has been possible to carry out the work regardless of the traffic (on double lines) and the capacity has averaged 360-m of track during a 9-h day. On some days as much as 440-m of track has been laid.

[625 .143 (42)]

Long-welded rails laid in continuous operation.

Method adopted by North Eastern Region allows one track-mile to be laid in 600-ft. lengths in one continuous operation.

(From The Railway Gazette, November 21, 1958.)

The Chief Civil Engineer's Department of British Railways, North Eastern Region, has devised and adopted a method of laying long-welded rails. Such rails up to 300 ft. are already in use in a number of places. Until quite recently the method used in Britain has been to unload them from the carrying wagons on to the permanent way and then to manhandle them into their seatings. With the new method it is possible to lay in approximately one track-mile of long-welded rails in one continuous operation.

Unloading from rear of train.

A train of 11 « Salmon » type bolster wagons, with a total length of about 700 ft., is used. Up to 36 welded rails, 300 ft. long, can be loaded on to the bolster wagons at the new rail welding depot at Dinsdale, near Darlington, described in last week's issue. Pairs of these rails are fish-

Pairs of 300-ft. rails fishplated into 600-ft. lengths being drawn off 700-ft. long train of 11 « Salmon » type bolster wagons.

plated together to form 600-ft. lengths. Eventually continuous welded rails 600 ft. long will be available. The rear wagon of the train has special gantry equipment designed for guiding the lengths of rail off the wagons at normal rail spacing of 4 ft. 8 1/2 in. and for lowering the rail ends.

Before starting laying-in operations, the rail ends are anchored to the track by 60-ft. steel wire ropes. The 11 wagons are long rails are then fishplated to the existing track and the wire ropes removed.

Thereafter the train is kept moving at a constant speed of about 30 ft. a min. The short rails are tipped out in pairs as the rear wheels of the last wagon move clear, and the 600-ft. rails are guided into their sleeper seatings by men using bars. When the free ends of the first pair of 600-ft. rails have reached a position on the

Rear bolster wagon, showing equipment for guiding rails at 4-ft. 8 1/2-in. spacing into their sleeper seatings, and gantry equipment for lowering the ends of the rails when the operation is completed.

drawn forward by a 350-HP Diesel-electric shunting locomotive until the first 70 ft. of each pair of rails is clear, and the ends of each length have been deflected down to the level of the rail in the track. During this part of the operation the first pair of existing short rails is tipped out manually from its sleeper seatings. The train is brought to a stand and the ends of the long rails are put into position in the vacant sleeper seatings. The ends of the wagon next to the gantry wagon, the train is stopped and the rails are fishplated to the second pair of 600-ft. lengths. This cycle of operations continues until the last pair of rails is being drawn off.

When only 2 ft. or 3 ft. of long-welded rail remains to come through the last pair of rollers the train is stopped and the rail ends lifted just clear of the bottom rollers by chainlifting blocks suspended from a lowering gantry. The train then moves

forward a few feet and when it is stationary the rail ends are lowered into their sleeper seatings.

Portable telephone equipment is used for communication between the engine and the gantry wagon of the train.

This method of installing long-welded rails was used on the East Coast Main Line between Beningbrough and Tollerton on November 13. The section was laid with 109-lb. F.B. rail on concrete sleepers, with « A.D. » type fastenings. So far as can be ascertained this was the first time that this method of laying long-welded rails has been adopted.

[621 .392 (43)]

Building up wagon and locomotive tyres by means of submerged arc welding,

by Adolf TUREK,

Engineer attached to the Ministry of Transport, Prague.

(*Deutsche Eisenbahntechnik*, No. 10, October 1957.)

Revised text of a lecture given to the 2nd Science of Transport Congress held at Dresden, from the 14th to the 16th June 1956. After a brief reference to the well known fundamental conditions involved in building up the flanges, the author reviews the trials carried out by the Czechoslovakian State Railways (Č. S. R.) regarding the reutilisation of tyres and in particular the metallurgical improvement of the weld metal. The remarkable results obtained thanks to the perfecting of a special type of submerged arc welding (UP process) in the completely automatic German built plant led to the introduction, also sucessfully, of welding of the flanges of the wheels of all types of power units and locomotives. Metallurgical and statistical investigations have proved the excellent utilisation of this repair method. Its introduction on other transport organisations, both in the German People's Republic and other national railways, as well as on mining and metallurgical railways, is to be expected in view of the work problem described and the steps taken to solve it.

1. Initial principle of the method.

One of the great economic problems in the utilisation of railway locomotives and wagons is to increase the possible service life of the wheels of the locomotives and wagons. On lines with many curves the increased friction on the sides of the flanges leads to more pronounced wear than that occurring on the running surfaces of the tyres. On curves, the tyres have to stand up to considerable pressure as a result of the acceleration stresses and centrifugal forces. On the Czechoslovakian Railways, about 40 % of the total length of the lines is on curves about one third of which of 300 m radius or less. Consequently, it will be appreciated that the tyres are subjected to exceptionally high stresses. On the locomotives, the result is extraordinary wear of the flanges, particularly those of the first and last coupled axles. To assure the guiding of the railway vehicle on the line, it is essential to return the tyres in order to restore to the prescribed form the modified profile. But this operation considerably reduces the thickness of the tyre (fig. 1).

Turning means that the tyre loses a great quantity of metal uselessly. The useful life of the wheels is reduced thereby, especially as the other tyre of the same

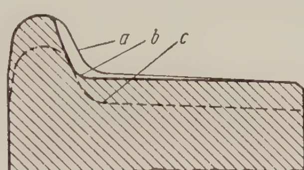


Fig. 1. — Tyre wear.

a. Initial profile;
b. Worn profile;
c. Losses without building up.

axle and, in the case of locomotives, all the driving and coupled wheels have to be restored to the same diameter as that with the greatest wear. This method of making good the wear by simply turning the tyres is not merely costly; it also imposes a heavy burden on the machines in the wheel shop, as well as on the production capacity of the steel industry. Leaving aside for the moment the possibility of lubricating the track and the Czechoslovakian Railways for many years. The added metal used for some time for this purpose, which had a C content of 0.45 % and Mn of 0.8 %, was very unfavourable from the welding point of view. For wagon wheels, type « RS 3f » automatic machines built by the former AEG factory at Hennigsdorf, now the VEB Lokomotivbau-Elektrotechnische Werke « Hans Beimler » (fig. 2), were used.

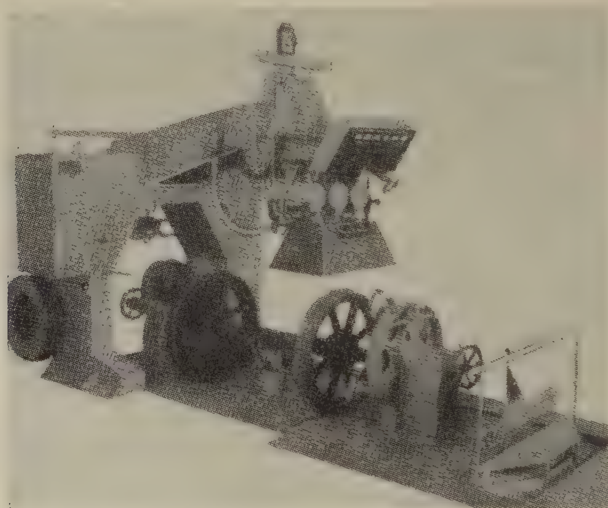


Fig. 2. — Installation for welding the flanges of wagon wheels, RS 3 f, adapted for welding with three bare arcs.

tyres, or of hardening the surface of the tyres, building up the worn flanges by welding is still the most advantageous method of prolonging usefully and economically the life in service of the wheels. Naturally, the turning of the built up flanges is limited to cleaning up the surface of the tyre, so that the loss of metal is always reduced to the minimum.

2. Technological evolution.

The building up of the tyres of wagon wheels which are worn and have become sharp has already been practised on the

These installations are equipped with a turning and oscillating locking device, as well as three welding points, which can be independently regulated, and three corresponding transformers, with a maximum output of 300 A. As electrodes, formerly the Böhler type « BW » were used, which assured the added metal would be easy to machine. Later on, the tyres were welded temporarily by means of a mark « Be 38 » Czechoslovakian electrode 5 mm in diameter. This electrode with its low carbon content could not, it will be appreciated, give satisfactory results. The great atomization of the

electrode led to irregular building up of poor shape which, owing to the action of the air, contains considerable quantities of oxides, nitrates and pores (fig. 3).

The welding of locomotive tyres, which have a still higher carbon content than the tyres of wagons (about 0.7 C, up to 1.1 Mn) and consequently a greater tendency to become hardened, was a difficult problem. Trials of welding by hand, still with the bare mark « Be 38 » electrode, made without any preliminary preheating, gave results which were completely unsatisfactory. The metallurgical phenomenon was unfavourably influenced by the choice of this unsuitable building up metal, as well as by the absence of heat treatment, so that all subsequent operations showed traces of non-consolidation. The trial welds also showed various defects, such as, for example, cracks of different dimensions and pores, defects of penetration and marked notches at the edges of the runs of weld metal as well as definite fissures of intercrystalline character. The nitrogen in the weld increased the hardness, and perhaps also the resistance to wear of the added material, but on the other hand, considerably reduced its strength, which was mainly revealed in the parts subjected to dynamic stress by an increased tendency to flaking.

The welding then carried out on a locomotive tyre by means of a heavily coated basic electrode, such as Č.S.R. 62.3/BH/70, was on the contrary homogeneous; the uniformly applied runs showed no macroscopic defects. With the application of preliminary heating between 250 and 300° C, good results were regularly obtained from the point of view of the way the wheels stood up in service. This method of welding, which can be used in any shop without any special installations, was obviously a possibility, but it is not very productive and means having a qualified and conscientious welder. This is why building up tyres by hand welding by means of a coated electrode is only authorised in exceptional and extremely urgent cases. To making the repairing of the tyres of locomotive and wagon wheels by building up more economic, and to improve the quality, the best method is to make such an operation automatic.

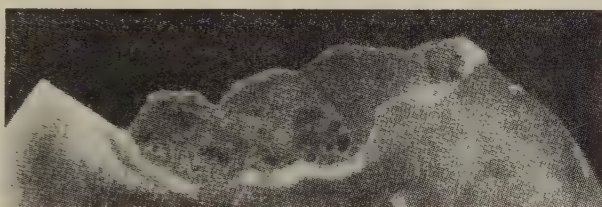


Fig. 3. — Macrography of a weld with ČSR mark Be 38 electrode, 5 mm dia.

As the Czechoslovakian Republic does not manufacture any special electrode for automatic welding similar to the « Böhler » type, another method of welding had to be adopted; this was submerged arc welding. Everyone knows the advantages of this method : first of all its great productivity, due to the high welding current, and as a result the great amount of added metal which is fused. When building up, it is not generally necessary to have a great depth of penetration into the base material. When building up on steel having a high carbon content, deep penetration may even be a disadvantage.

For the layer deposited to have the necessary mechanical characteristics, it must not

contain more than 0.2 % C. To avoid an increase in carbon in the weld metal due to carbon being absorbed from the base material, the method of building up selected must be one which prevents such a phenonemon as far as possible. Consequently, the base metal must participate in the weld as little as possible and the electrode on the contrary as much as possible. This is achieved, for example, by adopting a small diameter electrode and a relatively low welding current.

However, in the case of welding with a single arc, the productivity of the work as a result does not correspond to the considerable present day demand, so that it has been found essential to operate with several successive arcs. The second arc, and possibly the third, may produce more heat than the first, because they do not melt the base metal directly but the building up metal of the previous run now in course of setting. The percentage of the base metal contained in the additional metal is therefore smaller. The successive arcs improve at the same time the strength of the additional metal as well as the zone coming under the influence of the heat. The improved structure of the weld of the first arc is due to the fact that the heat from the second arc, and possibly the third, slows down the cooling below point A 3. The second arc already slows down the cooling of the transition layer and thus limits the risk of the formation of a hard zone along the first run, which would detract from its machinability. But the fragility resulting from too rapid cooling may be the source of other difficulties. The preliminary heating of the base metal to a suitable temperature consequently makes it possible to avoid the formation of an undesirable structure.

But besides these general principles on the building up of the tyres of locomotive and wagon wheels, which are acceptable in the case of metal having a medium carbon content, important conditions as regards carrying out the work also had to be taken into account. Amongst others, it was necessary for the building up installation to be easily manœuvrable, both as regards putting the pairs of wheels into the machine and the working of the automatic welding equipment. The materials to be added, amongst others the electrode and the flux, must as far as possible be of a type in current use and easy to obtain; their cost must be low if the method is to be profitable. The choice of these materials governs to a great extent the structure of the layer applied. The weld must in fact stand up in service as far as possible in the same way as the base metal. A lower resistance to wear is undesirable, as this will shorten the interval between repairs. Higher resistance to wear, on the other hand, will result in more rapid wear of the rails. For submerged arc welding « Z 41 » silicate of manganese powder is produced and used in Czechoslovakia, the composition of which is shown in Table 1.

Table 2 gives data concerning the composition of the types of welding electrodes used in the Republic of Czechoslovakia for submerged arc welding of the wheels of wagons, as well as of locomotives, tenders and railcars. For the moment, only types 1, 1*a* and 2 are in production.

The added metal contains a small proportion of manganese which takes the place of carbon, which burns to a great extent in the arc and consequently is only found in small quantities in the weld.

3. Building up the tyres of wagon wheels by submerged arc welding.

For building up the tyres of wagon wheels, several type RS 3f automatic machines, as already mentioned, were available, made by VEB-LEW of Hennigsdorf. At the end of the war, it was at first impossible to make use of them, because no « Böhler » electrodes were available. After studying the way these machines functioned, however, a simple reconstruc-

TABLE 1. — **Composition of the MnO SiO_2 flux powder « Z 41 »** (%).

SiO_2	MnO	Al_2O_2	CaO	CaF_2	Fe_2O_3	MgO	$Na_2O + K_2O$	P + S
41 to 43	40 to 46	5 max.	4.5 max.	4 to 5	1.5 max.	1.0 max.	0.5 to 0.8	each. max. 0.13

TABLE 2. — **Electrodes for submerged arc welding of tyres of wagons, locomotives, tenders and railcars. Composition** %.

Kind	C	Si	Mn	P	S	Cr	Ni
1	0.10 max.	0.05 max.	0.4 to 0.6	0.04 max.	0.04 max.	0.20 max.	0.30 max.
1*a*	0.10 max.	0.03 max.	0.4 to 0.6	0.03 max.	0.03 max.	0.15 max.	0.25 max.
2	0.12 max.	0.10 max.	0.8 to 1.1	0.04 max.	0.03 max.		
3	0.12 max.	0.07 max.	1.8 to 2.2	0.04 max.	0.035		

tion was found which made it possible to adapt them for submerged arc welding, as shown in figure 4. The alteration consisted essentially in the use of a 2 mm dia. electrode. With a current of approx. 200 A, this already gives a stable arc under flux. However, the speed of fusion of the rod is definitely higher than with the 5 mm electrodes used up to then with the open arc. As a consequence of altering the gear ratio in the welding head, the speed of advance of the electrode was multiplied by five approximately.

A tank containing approx. 40 kg of flux powder was added to the welding installation. This tank supplies the three arcs through a common tube fitted with a simple regulating register. The powder consumed in welding is then collected by an aspirator suspended above the tank to which it is returned. The flux which has melted and turned into slag is replaced from time to time by new flux. The powder is taken and kept close to the weld by a plate which bears elastically against the tyre to be welded, on the inside

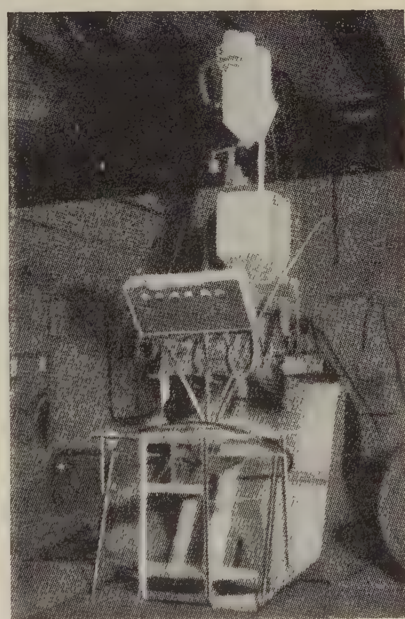


Fig. 4. — RS 3 f installation for welding tyres as altered for submerged arc welding.

of the axle. Figure 5 shows the altered « RS 3f » equipment, arranged for submerged arc welding.

The tyres of the wagon wheels are now generally built up by means of a 2 mm dia. wire type 1 and flux Z 41 of granulometry J (0.3 to 1.2 mm) (see Tables 1 and 2). The arrangement of the pairs of wheels, inclined to 60°, as well as the arrangement of the piping of the original installation have been retained. Building up therefore takes place in practice in a hollow, which is advantageous as the slope over the affected zone of the base material cools down slowly.

Trials have shown that the distance between the different successive arcs should not exceed 35 to 40 mm, so that the bath of liquid slag covering the run extends sufficiently far that is to the following arc. The transversal staggering of the arcs should amount to about 5 to 7 mm, to assure good continuity between the different runs. All the melted metal is thus joined together so that it covers the whole width of the flange. In most cases,

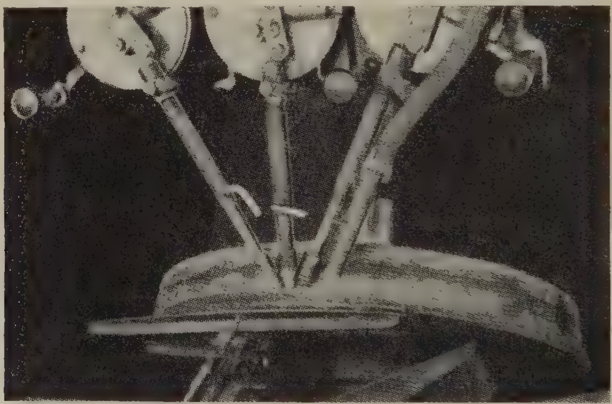


Fig. 5. — Arrangement of the three electrode tubes, the powder supply and arrangement for holding the powder.

of the tyre helps in forming the building up layer. Welding takes place by means of three arcs with D.C. of approx. 200 A and 32 V each, the electrodes being connected to the negative pole. The peripherical speed of the wheel is about 20 to 23 m/h.

With wagon tyres, it has been found that the metallurgical problems of building up with submerged arc welding under the conditions described above do not give rise to any difficulties. The building up by means of three arcs working simultaneously, in particular, is advantageous, because the proportion of base metal in the weld diminishes considerably and more- a single run of added metal is sufficient and only in the case of extremely worn flanges are two runs needed. The pipes should not be more than 30 mm from the tyre. Before welding, it is necessary to clean the tyre to remove all traces of rust and grease, in order to prevent the formation of pores. The method which has been found best is to rub the tyre with a rag soaked in paraffin, and then wipe it off. The tyres of wagons are not heated before being built up.

Building up carried out as described above gives a smooth surface, bright and uniform, with no serious surface irregularities as figure 6 shows. Figure 7 shows

that the transition between the weld runs of the different arcs, as well as between these and the base material, is free from defect of continuity. Likewise no defects

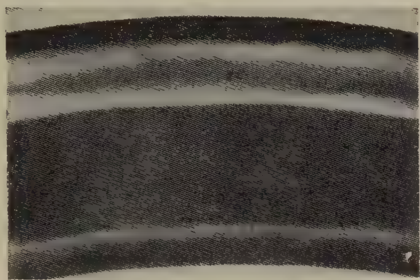


Fig. 6. — Surface of the building up weld run by submerged arc welding, with triple electrodes.

can be seen, such as in particular the formation of fissures in the actual weld.

A comparison of the composition of the building up weld metal and the base metal gave the results shown in Table 3. The analysis shows that the carbon content has decreased in the weld and that the proportion of Mn and Si has increased owing to these being taken from the flux powder.

The metallurgical study was concerned above all with the presence of unfavourable hardened structures which would impede the machining of the built up tyres, and moreover might be the cause of broken tyres. The risk of hardening is the greatest in the transition zone with the base metal, which during the building up operation is raised to a temperature of between A1 and A3, and then cooled off relatively quickly. The structure at this point is shown in figure 8. In this case the structure is heterogeneous with the remnants of the ferrite and lamellar perlite system. This zone, however, has no martensitic structure. Figure 9 shows the structure on the outside face of the actual weld, and figure 10 the structure of the base metal.

Fig. 7. — Macrography of the build up by submerged arc welding with three electrodes carried out on a wagon wheel set at a slope of 60°.

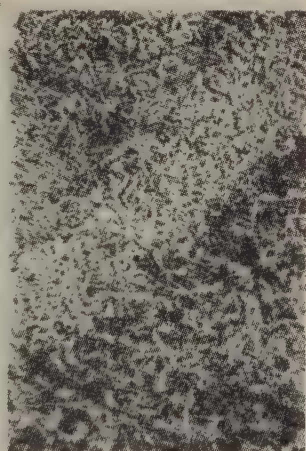


Fig. 8. — Micro-structure of the transition between the metal of the tyre and the building up metal (× 100).

TABLE 3. — **Analysis of base metal, weld and electrode used with wagon tyres.**

	Base metal	Weld	Electrode (type 1)
C	0.042	0.07	0.10
Mn	0.52	0.72	0.35 ... 0.60
Si	0.29	0.37	max. 0.03
P	0.021	0.041	max. 0.04
S	0.031	0.029	max. 0.04

The results of the metallographic study also confirm the determinations of the variation in the hardness of the base metal up to the edge of the building up metal. The different soundings were made 0.5 mm apart and in three series as shown in figure 11. Each of them went through a weld run perpendicularly to the transition. The results found are shown in figure 12. These clearly show that the different arcs have a great influence on the hardness of the existing weld runs in the transition zones. The maximum hardness is found in the transition zone of the run made by the last arc. A moderate increase in the hardness of the transition zone does not matter as far as the machining is concerned.

Fig. 9. — Micro-structure of the surface of the weld run (× 100).

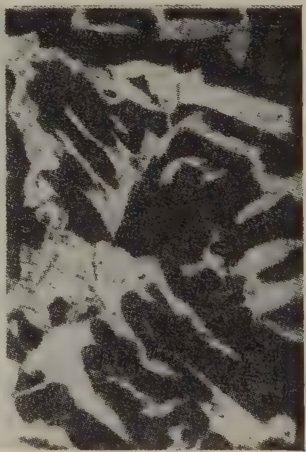


Fig. 10. — Micro-structure of the tyre metal (× 100).

The hardness of the actual weld is less than that of the metal of the tyre, owing

to its reduced carbon content. Prolonged trials in service have however shown that the resistance to wear of the layer added answers entirely on operating requirements, so that the period between repairs normally obtaining remains unchanged.

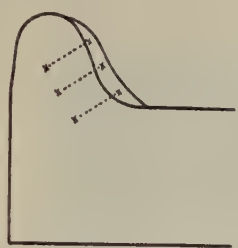


Fig. 11. — Arrangement of the hardness tests.

In sum, it can be said that the quality of the built up tyres for wagon wheels with the submerged arc welding system described is extremely satisfactory; the operation of the automatic welding equipment is not any more difficult as a result of the alterations made. The productivity of the work is very high, when it is considered that in one hour actual welding nearly 10 kg of metal can be added, with a consumption of 12.5 kg of flux in powder.

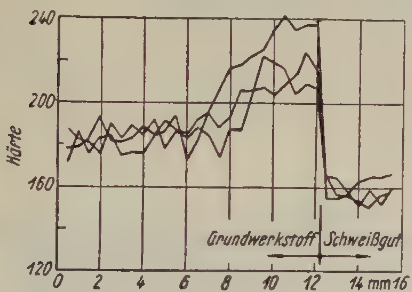


Fig. 12. — Variation in the hardness on wagon tyres welded by the submerged arc method.

N. B. — Härte = hardness. — Grundwerkstoff = base metal. — Schweissgut = deposited metal.

4. Building up the tyres of locomotive, tender and railcar wheels.

Building up the tyres of locomotive wheels presents considerably greater difficulties than in the case of wagon wheels, because the base metal of locomotive tyres has in principle a higher C content, so that the risk of hardening is increased. On the other hand, there were no installations in the repair shops of the Czechoslovakian State Railways allowing of the mechanisation of the work of building up the tyres of locomotive wheels.

Welding centres for building up locomotive wheel tyres with the submerged arc system were therefore created, using any equipment available. The question of designing apparatus for holding the pair of wheels in which it could be fixed as simply as possible was of capital importance. After suitable modifications, arrangements used for other purposes were used provisionally. In this case the axis of the axle is horizontal. The speed of rotation of the assembly can be regulated to a certain extent, in order to give the prescribed building up speed with different diameters of tyres.

For the actual welding installation, two semi-automatic welding equipments of the Czechoslovakian Railways, type « SPK » (fig. 13) with short cables, were used, the supports of which are fixed to two light cross shaped supports. In this way, it is possible by moving the pipe-holders to deposit the different weld runs uniformly one beside the other, and obtain progressively the section desired. The two arcs are supplied with flux from a common reservoir. The surplus powder is collected in a receptacle after passing through a sieve which separates out the slag. Above the powder reservoir, an aspirator can also be installed to return the powder to this reservoir. Here again, Z 41 powder is used for the job, with « J » granulometry (0.3 to 1.2 mm), but with a No. 2 rod, 2 mm in diameter.

The two arcs, working one after the other, also deposit the metal at intervals of 35 to 40 mm. The first receives a current of 180 to 240 A with a tension of 32 V, the second works at approximately 250 to 300 A at 34 V. The circumferential speed at the flange of the tyre during to make a thicker layer. Figure 14 shows how the building up is done on the side of the flange, which is set so as to be practically vertical.

Building up under these conditions is smooth, with a bright surface and has lateral undulations formed by the overlap-

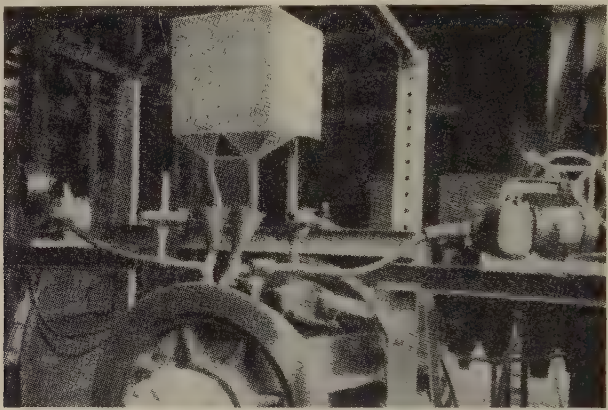


Fig. 13. — Temporary installation for submerged arc welding of locomotive, tender and railcar wheels.

welding reaches 35 to 40 m/h. Direct current can be used, the electrode being connected to the positive pole.

As it is necessary to heat the tyres before building them up, each working post is equipped with blowlamps for heating. These must be sufficiently powerful in order to reduce the time required for this heating. Before welding begins, the tyres are raised to a temperature of 250° C, and this temperature is maintained all the time welding is taking place. The control of the heating is done by means of fusible sticks.

The tyres have to be cleaned before being built up, in order to avoid the formation of pores. The use of a rag soaked in paraffin has been found satisfactory. The remnants of the paraffin are burnt away during the preheating of the tyre.

The weld runs are superimposed so as

ping of the different weld runs. The transitions between the different runs and the base metal show no notches; no welding defects nor fissures have been noted. Figure 15 shows a section of a built up locomotive tyre.

Fig. 14. — Building up by means of submerged arc welding on a locomotive wheel set held horizontally, in a temporary installation.

Table 4 gives the composition of the base metal of the tyre, as well as that of the deposited metal. As in the case of wagon tyres, there is a reduction in the carbon content and an increase in the manganese and silicium content.

The metallographical study once again verified the structure from the point of view of hardening. Figure 16 shows the structure at the transition between the weld run and the base metal, which was heated during the building up operation up to the austenitic field. This structure shows clearly that cooling took place rapidly, but martensite has not been found in any part. Figure 17 shows the structure of the weld near the surface of the weld run, and figure 18 the base metal intact.

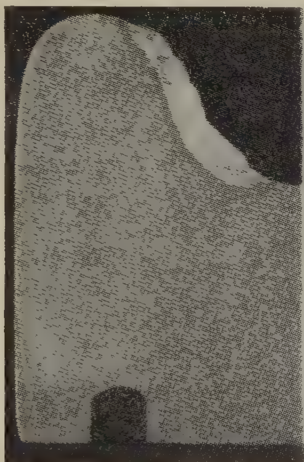


Fig. 15. — Macrostructure of a locomotive tyre built up by submerged arc welding in the hozirontal position.

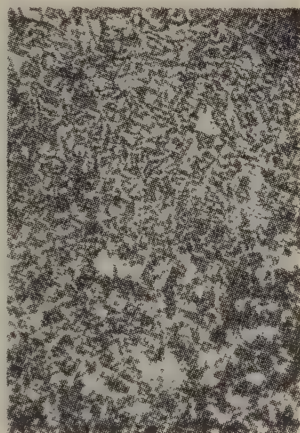


Fig. 16. — Micro-structure of the transition between the tyre metal and the building up metal (× 100).

TABLE 4. — **Analysis of base metal, weld and electrode, in building up locomotive tyres with submerged arc welding.**

	Base metal	Weld	Electrode
C	0.68	0.17	0.10
Mn	0.62	0.99	1.15 ... 1.35
Si	0.27	0.41	max. 0.10
P	0.035	0.046	max. 0.04
S	0.029	0.027	max. 0.04

The result of the metallographic study has also been confirmed by measuring the hardness, in the same way as for wagon tyres. The variation in the hardness found in the non-affected base metal and up to the surface of the weld is shown in figure 19. The variation in the hardness in the different series of measurements is not the same; it differs considerably according to the degree of tempering caused by the following weld run. The hardness of the actual building up metal is slightly lower than that of the base metal, due essentially to the lower carbon content.

Fig. 17. — Micro-structure on the surface of the weld run ($\times$ 100).

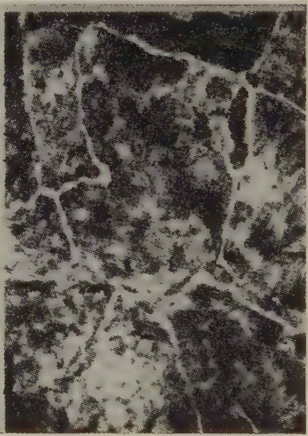


Fig. 18. — Micro-structure of the metal of the locomotive tyre ($\times$ 100).

Figure 19 has been completed by also showing the variation in the hardness of an insufficiently heated tyre (up to about 150° C only). The machinability of the built up locomotive tyres is good, but rapidly decreases if the proper preheating temperature is not observed. The machinability is therefore to some extent a check on the technological operation.

Service trials to ascertain the resistance to wear carried out over a long period on several locomotives running on different lines have shown that the average wear of the tyre at the flange amounts to about 1.8 mm per 10 000 km, which corresponds to the way tyres that have not been built up stand up in service. With the operations described above it is therefore possible successfully to build up the tyres of locomotives, without any risk of dangerous modifications in the base metal. With the use of the materials indicated, it is possible to obtain in ordinary practice building up welds of a quality similar to that of the base metal. With a consumption of 7 kg/h of the powder flux, a deposit is obtained, as a function of the actual duration of welding itself, of about 5.6 kg/h. To conclude it must also be pointed out that the tyres of tenders and railcars can be built up in the same way.

5. Appreciation of the repair method in general.

Below we list the number of tyres welded by the submerged arc process described, their behaviour in service, the

economies obtained, and give the improvements made to the welding of flanges. The welding of all types of tyres described above was made the standard practice in the second quarter of 1954. Since then, a fairly large number of temporary installations for building up the tyres of locomotive wheels have been set up; on the other hand, nearly all the old automatic AEG welding equipments have been converted for submerged arc welding. The number of tyres built up in these last years is shown in Table 5.

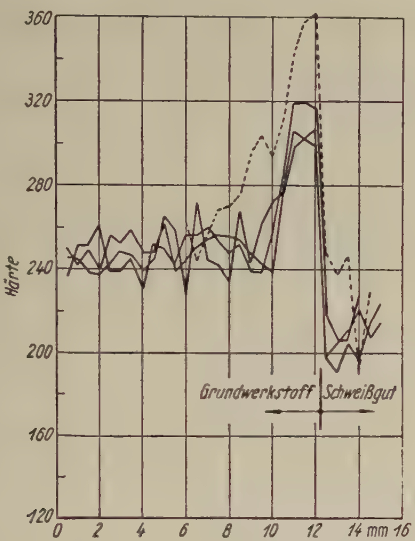


Fig. 19. — Variation in the hardness on locomotive tyres built up by means of the submerged arc welding process.
———— preheated to 250° C.
— — — — preheated to 150° C.

N. B. — Härte = hardness. — Grundwerkstoff = base metal. — Schweissgut = deposited metal.

A comparison between the cost of repairing tyres by turning and by building up by welding has shown the great economies obtained with the latter; this amounts in the case of a wagon tyre to about 113 Czechoslovakian crowns, and to about 165 crowns per locomotive tyre.

The pairs of wagon wheels built up as described with the submerged arc method have not given rise to any operating incidents; on the other hand, at the beginning four cases of damage occurred, three of them with locomotive tyres, and one with a railcar tyre. But the investigations then made showed that the locomotive tyres had only been heated to 150° C, i.e. insufficiently. In the case of the railcar tyre, this was built up when cold, although in view of the composition of the material of which the tyre was made, it was essential to heat it.

The problem of building up wagon tyres must therefore be considered as solved by the method described, as far as this process is concerned. To rebuild loco-

TABLE 5. — **Number of tyres built up by the submerged arc welding method on the Czechoslovakian Railways.**

Year	Locomotives, tenders, railcars	Coaches and wagons	Number of tyres per annum
1954 (second half-year)	864	4 478	5 342
1955	3 204	13 194	16 398
1956	2 320	13 424	15 744
1957 (first half-year)	1 356	9 398	10 754

motive tyres, the VEB-LEW « Hans Beimler » establishment at Hennigsdorf is designing and building a special installation in collaboration with the experts of the Czechoslovakian Railways. The general arrangement will be similar to that of the welding installation for wagon tyres. However, it is essential that it should allow of the welding as far as possible for very different types of axles from the point of view of type and dimensions for the greatest possible number of the existing steam and electric locomotives, as well as tenders and railcars. The new installation will also be equipped with a device enabling welding to be carried out with three arcs.

In order to improve constantly the resistance to wear and increase the period between the different repairs, prolonged trials are to be carried out in service on tyres built up by means of different types of electrodes and powder. In addition, trials will also be made regarding the superficial tempering of built up tyres.

[669 .1 : 625 .285]

The use of stainless steel on railway vehicles, considered on the basis of the double railcar of the firm Linke-Hofmann-Busch GmbH.,

by Dipl. Ing. Heinz ALTEN, Salzzitter-Watenstedt.

(*Glasers Annalen*, No. 6, June 1958.)

In the construction of railway vehicles, the objectives to be aimed at are fortunately defined, at least in principle, with a clarity which is quite exceptional in technical matters. These are :

Maximum comfort as regards the arrangements and running stability;

Minimum weight and lowest possible cost to buy and maintain.

The multiplicity of these conditions begins to become apparent as soon as taste and sentiment become the criteria on which values are based and the draughtsman, working on the solid basis of concrete facts, does not escape their influence. The circle of criticism which does not suffer from excessive competence is particularly great on this point and if only because sheer weight of numbers, has such an influence that logical studies are often found embellished with grotesque arabesques.

However, a brief glance at the way in which attempts have been made to realise the above conditions, which are often contradictory in themselves, shows that there has been well-balanced continuity. The characteristics of the most remarkable stages in the evolution which has occurred in the case of the body of coaches make it possible to draw the curve of the evolution of the characteristics of the present phase, which is in transition between weight reduction due to the design and weight reduction due to the materials used.

The most striking stages of this evolution are :

Wooden framework covered with wooden panels; riveted steel construction; welded steel construction; then at certain intervals but on the whole parallel to this evolution : construction using sections and sheets, shell-type construction in its various forms, with thick and thin sheets, many or few stiffeners, use of spot welding, and on this foundation, the introduction at the present time of new constructional materials, such as aluminium and stainless steel.

The primitive conditions : to build by using a more or less appropriate material a moving container for transport purposes has finally evolved into the present type of coach body, which fulfils a great number of conditions. In the various stages of its evolution, the factors which dictated this evolution are clearly seen, viz :

To assure economy and safety, the use of steel, replacing of riveting by welding and spot welding;

To reduce the weight : the various types of shell constructions conditioned by economic reasons : construction in thin sheet and construction in thick sheet, as well as trials to obtain reductions in the weight by replacing construction in sections by construction in sheet, and the next stage, weight reduction through the materials used, with the introduction of new constructional materials, such as aluminium and rustless steel.

The condition of weight reduction obviously dominates in view of its importance all the other factors affecting the

coach body. The additional cost of the materials is accepted for aluminium and rustless steel; in the case of aluminium the retrogressive step from welding back to riveting is accepted, and one of the fundamental principles of the evolution: minimum cost price is discarded. But will the introduction of weight reduction through the materials used, in other words the use of constructional materials having a lower specific weight, make it possible to attain in every case the object in view? If owing to the predominant importance of light weight construction, the use of more costly new constructional materials must be considered, we consider it is necessary to establish a basis for the appreciation of light weight construction, which should not be limited solely to the precise definition already elaborated, but should also establish between the constructional characteristics a mathematical relation which will enable a coefficient of quality to be established like that already established for the running qualities of railway vehicles. All the weight comparisons to be found in the different publications, which obviously are prepared with the ordinary intention of demonstrating the superiority of such and such a material over such another, err through the fact that vehicles subjected to the most diverse stresses are compared with each other. There is never any difficulty, by selecting suitable objects for comparison, in arguing for or against the use of any material, at least as regards its application in light weight construction. The often quoted coefficient, giving the ratio between the weight of the bare body and its length is doubtless the criterion of appreciation most often used. But it gives absolutely no information about the loads which the construction has to support, in other words it lacks any relation giving the degree of utilisation of the construction in question. It is the same for the amount of weight reduction expressed by the ratio of the moment of inertia to the gross weight of the stress carrying structure. It is only a combination of these two indications together with the load carrying capacity of the structure, with an indication of the ratio of the maximum possible load to the useful load in service which gives a coefficient of value allowing of a direct comparison of all the constructional arrangements from the point of view of the economic utilisation of the materials and the weight reduction obtained with the design. Besides these purely operating conditions, the calculation of a structure is subject to secondary limits, the result of static and dynamic considerations. The carrying structure is first of all dimensioned according to its load capacity; the admissible stresses set the limit. Another limit is fixed by the admissible deformations, in other words by the elastic behaviour of the whole, which in its turn limits the load capacity owing to the resulting oscillations. In addition, the behaviour from the point of view of the actual oscillations of the whole influences the vibrationary properties of the springs-mass system, and consequently the running qualities of the vehicle. The construction must be utilised up to the admissible limit by both methods of stresses. It is only thus that the optimum user of the materials is obtained.

A very simple example shows the prudence that is necessary in choosing the material if the minimum weight is the object in view and the astonishing consequences that can result from the vast scale of the most diverse stresses. A hollow cross beam with a space of 19 000 mm between its supports, having a height of 3 050 mm and a width of 2 825 mm, the moment of inertia being uniformly divided between the upper and lower bearing plates, so that the vertical uprights can be of negligible thickness, has to carry an overload of 10 t and have a frequency of 15 Hz. Such a beam will meet existing railway requirements. This beam will weigh:

in aluminium	2 015 kg
in steel	1 940 kg

these two weights obviously representing in each case the indispensable minimum for meeting the conditions laid down. This example already shows that the reduction in weight due to the reduced density of aluminium is not completely realisable, and according to the length of beam required, with optimum user of the material there may occur a situation in which steel, or rustless steel, will allow of the construction of a lighter body framework than aluminium. The longer the body and the wider the space between pivots, the more the advantages of using steel become apparent, whereas in the case of short coaches aluminium is undoubtedly superior as regards the saving in weight.

The comparison hereafter (Table 1), which is concerned with certain special vehicles has no doubt the same defects as we reported above, but shows nonetheless the accuracy of our reasoning, even in the case of the example calculated. These reasons to some extent led the *Linke-Hoffmann-Busch Co.* to study in 1955 and 1956 with the collaboration in the field of special steels of the firm of *Capito & Klein*, a railcar built entirely of rutless steel.

This study had to cover amongst other considerations :

a) the development of a small railcar into one of increased capacity;

b) the improvement of its running qualities by the use of bogies without increasing the favourable tare per seat already obtained in the small Uerdingen railcar;

c) the designing of a vehicle requiring the minimum of maintenance and capable of running in tropical and sub-tropical countries. This condition was due to the numerous enquiries received from abroad, concerning vehicles made of rustless steel.

This condition was met with the vehicle which we will now briefly describe. The prolonged interest roused by this construction in Germany and beyond show that the path taken was the right one.

Description of the construction.

The whole of the body of the coach, including the panels, are of nickel-chrome rustless steel. The metal used for the framework of the body is of the V2A extra quality, that used for filling in of the standard V2A quality. V2A is the com-

TABLE 1.

Designation of vehicle	*Material*	*Buffer loading* t	*Length over buffers* mm	*Weight of body bare* kg	*Weight per metre* kg/m
1937 light weight express coach . .	St 52	200	21 270	6 856	322
German TEE rake.	St 37 St 52 Al F32	150	17 400	4 854	278
1953 articulated rake.	Al	150	11 600	2 100	182
Pioneer III	V2 A	150	25 958	11 795	454
VBS railcar	V2 A	350	19 132	4 633	242

mercial name of an austenitic steel with about 18 % chrome and 9 % nickel. V2A steel was the first rustless steel to be used on a large scale industrially. It still holds the front rank amongst rustless steels. It is used wherever it is necessary to have great resistance to rust and acids, as well as the good manufacturing qualities which is a characteristic of austenitic steels. The designation « extra » means that the titane has been added to stabilise the proportion of carbon. This ensures that no modification of structure takes place when welding is used, which might have unfavourable repercussions on the chemical stability of the area in question as a result of intercristalline corrosion.

Standard V2A does not include this stabilisation by titane. But the thin sheets of standard V2A can be assembled by spot welding, seam welding or arc welding, if they are only subjected to the action of the humidity of the air.

These two qualities of the material have, in addition to their excellent weldability and high resistance, a considerable tensile strength, varying between 55 and 75 kg/mm². These steels are delivered in the form of sheets or wide flats.

The stability of rustless steels resistant to acids, depends essentially upon their content of chromium. A proportion of at least 12 % chromium is essential; over 12 % the rust-resisting property increases very rapidly. Consequently, nothing lower than 17-19 % of chromium should be used for steel required for railway purposes.

In the United States, for many years, in the construction of vehicles, use has been made in addition to these chrome-nickel steels, of a chrome-manganese steel with a lower nickel content, similar in structure, which would also be an interesting proposition in Europe in view of its favourable price. The cost of this chrome-manganese steel is in fact lower than the cost of chrome-nickel steels by some 15 to 20 %.

The double Diesel railcar (fig. 1) is built to run in either direction, and has all the characteristics of the small railcars (railbus) of the Deutsche Bundesbahn. The unit consists of two motor units each with a complete system of propulsion. These two systems of propulsion can be controlled automatically or semi-automatically from whichever driving compartment is occupied. The two coach bodies are connected by a rigid centre coupling and mounted together on a carrying bogie. The two outer bogies are motor bogies.

Principal technical characteristics.

Total length of the double unit over buffers	38 264 mm
Length of a coach body over body end panels	18 450 mm
Motor bogie wheelbase	2 000 mm
Carrying bogie (Jakobs bogie) wheelbase	2 500 mm
Maximum speed on the level approximately	95 km/h
No. of seats in the double unit .	186
Standing room for	210
Weight approximately	40 t

Propulsion system :

Two *Büssing* U 10 water cooled Diesel six cylinder engines housed under the floor (continuous power of 135 HP at 1 900 r.p.m.);

Two *Mylius,* type T G 70 gearboxes, six speeds and reverse gear.

The coach body and carrying bogie are made entirely of special rustless steel of the quality indicated.

The stress carrying parts of the body (fig. 2 and 3) are made of folded sheets; the frame of the floor consists essentially of the head stock, of closed boxform, the two outer lateral sole bars, the main bolster above the motor bogie, the headstock at the end with the rigid coupling, as well as the cross stays and other necessary reinforcements. The assembly of these constructional details is by arc or spot welding or by argon gas welding. The thickness of sheets used for the body

structure is : for the frame, 3,6 and 8 mm; for the body framework, 2 mm; for covering in the sides 1 mm and for covering the roof 0.85 mm. All the coach body and bogie sections (fig. 4) are made up of lengths of sheet, welded together.

Fig. 1. — View of VBS railcar.

Fig. 2. — Body framework.

As regards the arrangement of the interior, we would like to draw attention to a small detail which appears to have been introduced for the first time on a railcar with a high user. The window pillars are not covered with the usual panelling but by spraying perlon fibres applied electro-statically. This covering has the advantage of being dust-resistant, easy to apply, light in weight, and easy to maintain. For the period of over a year which the railcar has been in service, this type of covering has given every satisfaction. However, it is not recommended for large areas, as the insulating properties are insufficient.

Most of the rustless steel vehicles built up to the present have been designed according to the methods of the *Budd Co.* This is characterised by a corrugated outer covering formed of separate rolled sheets. In the arrangement adopted by the *Linke-Hofmann-Busch Co.,* unlike this arrangement and all others using rustless steel hitherto, for the first time the outer covering of the vehicle has been made in the form of smooth panelling. The condition of making use of such thin sheets to obtain a smooth outer covering depends upon the very extensive use of spot welding for assembling the outer covering to the framework of the coach body, because this is the only way of keeping the utilisation of heat within such limits as will make subsequently dressing of the sheets unnecessary. This is all the more imperative as the coach is not painted. The fact that considerable difficulties from the point of view of the technique of manufacture would occur was not overlooked, but it was also appreciated that compared with the *Budd* process this method of construction would reduce to the minimum the use of costly assembly arrangements

Fig. 3. Coach body (bare).

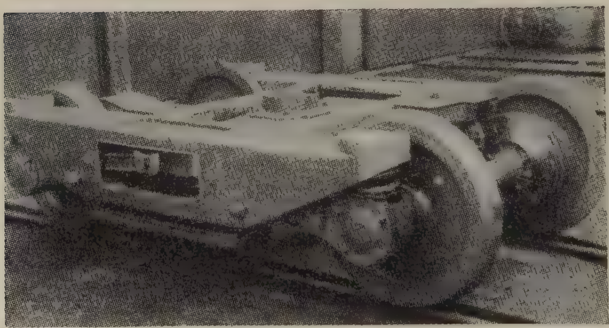


Fig. 4. — Carrying bogie.

and at the same time lead to savings in material. These considerations have proved well founded though only after many deceptions and readjustments. The weights quoted above (Table 1) show in addition that as regards weight reduction in the case of a railcar, appreciable progress has been made so that this type of construction, which is not absolutely to be recommended from the point of view of its strength, is nevertheless well justified. Moreover, it represents a concession to European public taste and corresponds to the desiderata often expressed by the Deutsche Bundesbahn as regards the outer covering of the body sides.

Economic considerations concerning the construction of vehicles in rustless steel are dominated by the question of the materials. With the constructional arrangements adopted by the firm of *Like-Hofmann-Busch,* it can be accepted that with vehicles made of St 37 steel and those of rustless steels, the labour costs only show infinitesimal differences compared with the cost of the materials. The comparison of the prices given below therefore covers the cost of materials and the savings obtainable in operation. Table 2 gives a comparison of the weight of a bare coach body made of St 37 steel. This table compares a coach body entirely made of St 37 steel, a coach with a framework of St 37 steel covered with V2A chrome-nickel steel sheeting or V2A chrome-manganese, a body made entirely of V2A chrome-nickel of V2A chrome-manganese, and an all aluminium body.

In this comparison, the additional cost due to the material used, the total cost of the unit and the saving of weight obtained in each case are compared. As regards the useful life of the vehicle, according to prudent calculations, it is likely that when rustless steel or aluminium are used, the maintenance costs of painting alone show a saving of 22 000 DM, which in the present case is more than enough to make good the increased cost of these materials. In the last column are

TABLE 2. — **Comparison of different combinations of materials and their repercussion on the overall cost of the railcar, and comparison of the economies obtainable.**

Type of construction	*Body coach bare*				*Total cost of coach*	*Saving on maintenance of paintwork*	*Saving due to the reduced weight (*)*	*Economic limit of operating costs*
	Weight	*Saving in weight*		*Cost of materials*				
	kg	kg	%	DM	DM	DM	tkm	Dpf/tkm
In St 37 steel throughout	11 444	—	—	6 924	416 924	—	—	—
Steel with V2 A chrome-nickel panelling	10 434	1 010	8.8	15 872	425 872	22 000	3 636.10⁶	~ 0
Steel with V2 A chrome-manganese panelling	10 434	1 010	8.8	13 960	423 960	22 000	3 636.10⁶	~ 0
Entirely in V2 A chrome-nickel steel	9 266	2 178	19.0	69 495	479 495	22 000	7 841.10⁶	0.517
Entirely in chrome-manganese steel	9 266	2 178	19.0	57 449	467 449	22 000	7 841.10⁶	0.364
Entirely in F 32 aluminium alloy	9 637	1 807	15.8	62 640	472 640	22 000	6 505.10⁶	0.518

(*) Annual mileage of 100 000 km; useful life : 36 years.

given the operating costs in Dpf/tkm for which the tkms saved on account of the reduction in weight exactly make up for the additional costs due to the materials; in the case of the higher operating costs per tkm, the saving due to the reduction in tkms covers them. These figures are so low that there is a very considerable excess. Other advantages must be added which, though very important, could not be included in the table in question; these are due to the simplification of the maintenance and corresponding reduction in the time the vehicle is out of service, the use of more drastic methods of cleaning which can be used to a limited extent only with the usual painted surfaces. All these considerations show that the use of special steels for such specialised kinds of vehicle is a very promising economic solution in spite of the relatively high cost of these metals.

Summary.

In the introduction, the author discusses the comparative criteria for appreciating light weight structures and draws attention to the fields of application of the different materials. He then describes a double railcar entirely built of rustless steel. In conclusion, he studies the influence of the cost of the materials and the saving in weight on the economy of the system.

Bibliography.

(1) Dr. Ing. CROSECK (« Konstruktion » 1954. No. 9) : « Die praktischen Grenzen des Leichtbaus bei Personenwagen für Schiene und Strasse in selbsttragender Bauweise ». (The pratical limits of light weight construction in the case of rail and road passenger vehicles of the self-supporting type).

(2) SCHMÜCKER « Glasers Annalen », No. 10, 81st year : « Der Wagenbau der deutschen TEE-Züge ». (The construction of the TEE German rakes.)

(3) Modern Railroads 1956 : Pioneer III.

Dr. Hermann BRAUN « Nirosta-Bleche; Verarbeitung von A-Z » (Rustless steel sheets - their use from A to Z). Editions Capito & Klein G.

[656 .22]

Mechanics of train running,

by O.S. Nock, B.Sc., M.I.C.E., M.I.Mech.E., M.I.Loco.E.

(*The Engineer*, December 19, 1958.)

The degree to which economic and engineering factors are bound up in the enterprise of running a railway, though appreciated in the broadest sense, has not always been fully implemented in the past. Much has been done in recent years to clear away some of the misconceptions, uncertainties and prejudices of old traditions, and in a recent paper presented to the Institution of Locomotive Engineers, Mr. S.O. Ell has collated a vast amount of data based on his work at Swindon. In this article the author, who has had the privilege of seeing something of this work at first hand, reviews and comments upon the paper.

It was as long ago as 1885 that the distinguished American engineer, A.M. Wellington, said : " It would be well if engineering were less generally thought of, and even defined, as the art of constructing. In a certain important sense it is rather the art of not constructing; or to define it rudely but not inaptly, it is the art of doing that well with one dollar which any bungler can do with two after a fashion. " That saying, of more than seventy years ago, might well be the battle-cry of all who are concerned with the job of trying to increase productivity to-day, and that would include everyone in the service of railways. Mr. Ell's paper strives to show how a precise knowledge of the mechanics of a train in motion can be used as a well-nigh priceless tool in the operational management of a railway. The theory is well known. It has been expounded, and commented upon, at length in the past by Lomonosoff, W.E. Dalby, and others; but the applications were in the majority of cases crude, if not downrightly inaccurate due to the rough and ready methods by which the experimental data were obtained. In his work as assistant, research and development (rolling stock) to the Chief Mechanical and Electrical Engineer of the Western Region, British Railways, Mr. Ell has been responsible for carrying out much very important experimental work with the former Great Western dynamometer car, and on the stationary testing plant in Swindon works, and it can now be said that perhaps the most hitherto elusive of all experimental quantities, train resistance, has been established to a high degree of accuracy, and from this fundamental quantity, Mr. Ell's work in the planning of train schedules has followed naturally.

At the outset, in displaying the time-table for a section of important main line in graphical form (fig. 1) Mr. Ell produced a virtual epitome of the whole problem of railway operation. He said, concerning this diagram : " Each line is the space-time relation of a train. The whole complex network shows the services provided to meet public needs within the limitations of the technical equipment. It reveals the traffic control. It signifies the veins and arteries of the enterprise. Yet each line can be precisely determined by the mechanics of the train. Formerly, whilst the traffic pattern remained uneventful in character and the technical equipment stable by nature, many of the functions of the mechanics of the train could be performed empirically and more or less passably. But when any novelty is about to be introduced, especially on a large scale, forward planning is impossible without the help of the mechanics of the train. It is absolutely essential in operation research, which is the only efficient way of obtaining maximum productivity of the enterprise at lowest cost, and of specifying technical equipment of the right type and the right power... "

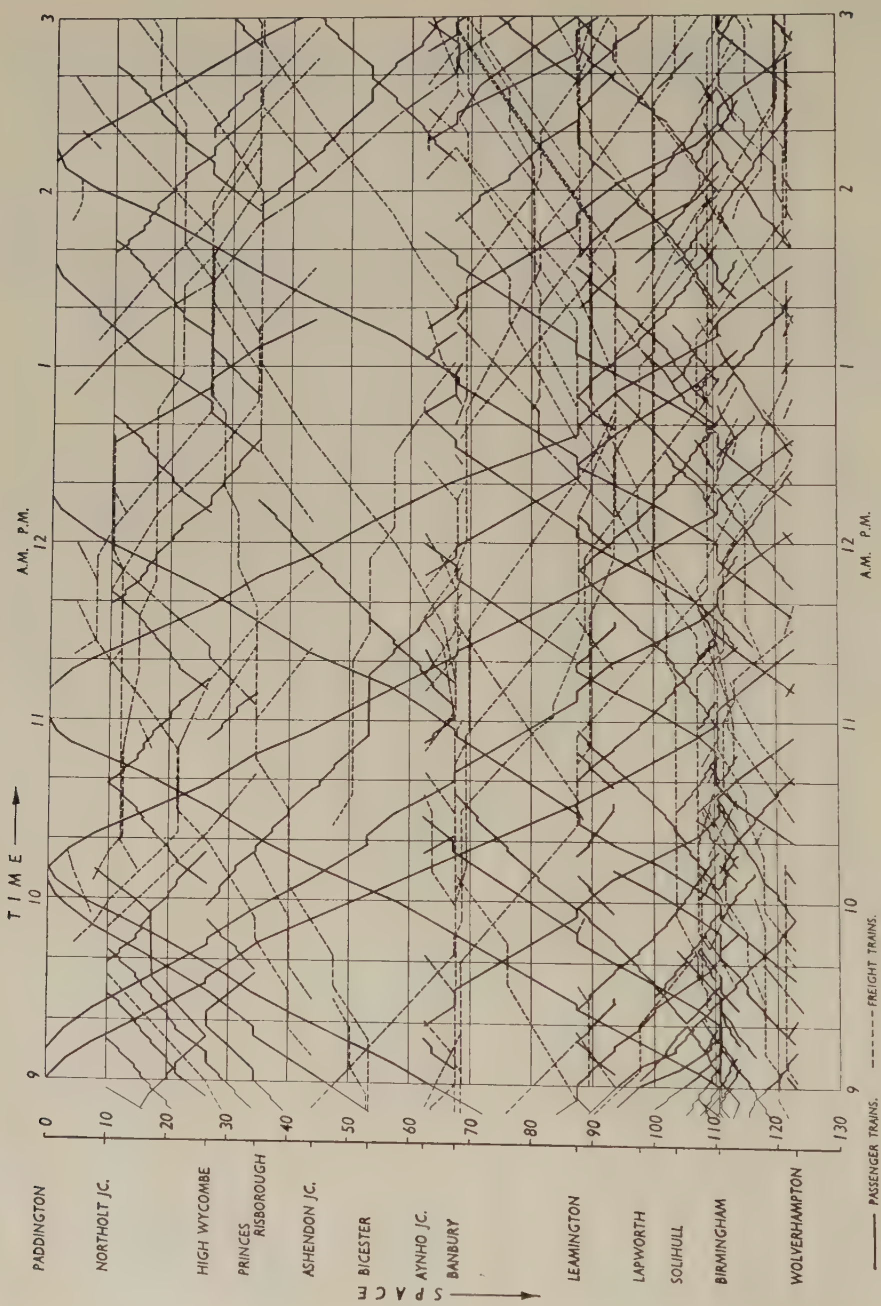
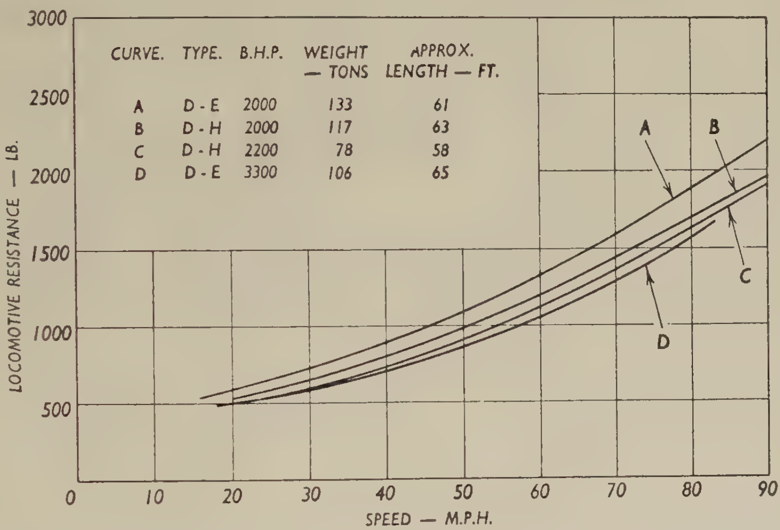


Fig. 1. — Graphical time-table diagram. Western Region, Paddington-Wolverhampton.

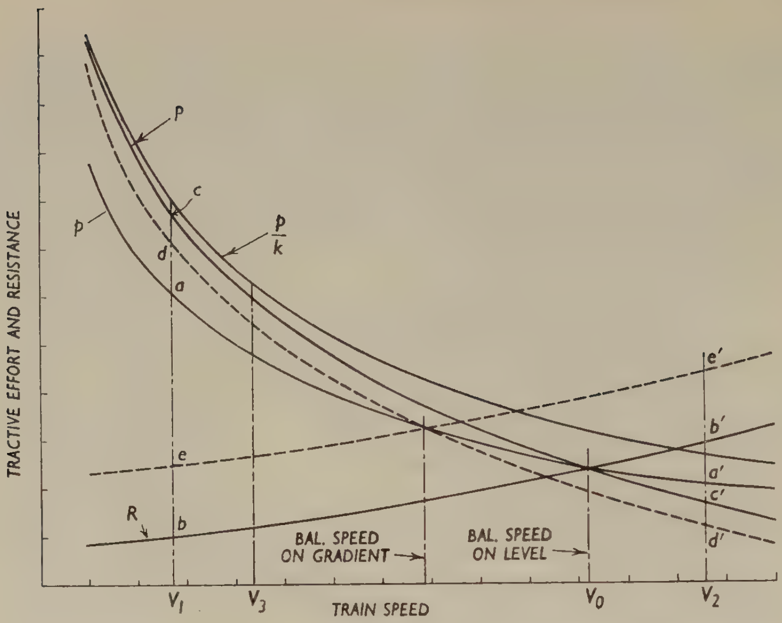
The diagram, figure 1, relating to the main line of the Western Region between Paddington and Wolverhampton, is worth a close study for its own sake. It shows clearly the paths of the through express passenger trains leaving Paddington at 9 a.m., 9.10 a.m., 10.10 a.m. and 11.10 a.m., and trains running at similar schedules in of railway enterprise that offers greater financial rewards for increased productivity than the drastic acceleration of freight train services, and with the fitting of continuous brakes to all vehicles, and the possibility therefrom of safe running at considerably higher speeds, the basic data of train resistance established in experi-



Curve reference	Type of locomotive	Nominal power, d.b.h.p.	Description	Weight tons	Approximate length, ft.
A	Diesel electric	2 000	" Southern " type	133	61
B	Diesel hydraulic	2 000	" Western " type	117	63
C	Diesel hydraulic	2 200	" Western " type	78	58
D	Diesel electric	3 300	" Deltic "	106	65

Fig. 2. — Resistance of locomotives.

the opposite direction, but it shows also the almost incredibly slow running demanded by the present time-table for some of the freight trains. One, for example, leaving Greenford at about 10.10 a.m. is no further than Princes Risborough at 3 p.m. in the afternoon! There is no field mental work, such as described by Mr. Ell, will be invaluable in the planning of entirely new time-tables. It should be emphasised, however, that figure 1 represents the planned time-table, on which daily running of the railway is based. The availability of precise data, both in respect



W_e = weight of locomotive;
W_c = weight of trailing load;

$n = \dfrac{W_c}{W_e}$;

$k = \dfrac{W_c}{W_e + W_c}$ = trailing : gross weight ratio.

F = fuel rate;
V_0, V_1, V_2, V_3, & c = train speed;
r_c = specific resistance of trailing load on the level.
r_e = specific wind and track resistance of locomotive on the level;
R = $r_c \times W_c$ = total resistance of trailing load on the level;
C = $r_c \times W_e$;
P = equivalent drawbar tractive effort or drawbar tractive effort on the level at constant speed = rail tracitve effort — $r_e W_e$;
p = tractive effort on trailing load or traction drawbar tractive effort (trac. d.b.t.e.).

Residual forces bc, $b'c'$, & c.

On level :
ab, $a'b'$ & c, acceleration force on trailing load;
ac, $a'c'$, & c, acceleration force on locomotive.
Locomotive and trailing load have same acceleration.

$$\text{Therefore : } \frac{ab}{ac} = \frac{a'b'}{a'c'} = \frac{W_c}{W_e} = n.$$

On gradient :
cd, $c'd'$ gradient component of locomotive;
eb, $e'b'$ gradient component of trailing load.

$$\text{Therefore : } \frac{cd}{eb} = \frac{c'd'}{e'b'} = \frac{W_e}{W_e} = \frac{1}{n}.$$

ad, $a'd'$ acceleration force on locomotive;
ae, $a'e'$ acceleration force on trailing load.
Locomotive and trailing load have same acceleration·

$$\text{Therefore : } \frac{ae}{ad} = \frac{a'e'}{a'd'} = \frac{W_c}{W_e} = n.$$

Thus p is not qualified by gradient and acceleration. Consider a given fuel rate F and speed V_3 as :

$$W_c = nW_e,\ R = nC \text{ and } k = \frac{n}{n+1}.$$

$$p = P - (P - nC)\frac{W_e}{W_e + W_c}$$

$$= P - P\frac{W_e}{W_e + W_c} + nC\frac{W_e}{W_e + W_c}$$

$$= P\left[1 - \frac{W_e}{W_e + W_c}\right] + nC\frac{W_e}{W_e + W_c}.$$

$$\text{But : } 1 - \frac{W_e}{W_e + W_c} = k \text{ and } W_c = nW_e.$$

Therefore : $p = Pk + Ck$.
Therefore : $p = k\,(P + C)$ . . . . (1)

Note :
(i) This result is independent of n and therefore holds for all values of n;
(ii) Thus for a given fuel rate and speed, P and C are constant, $p \propto k$ from (1);

$$\text{Therefore : } \frac{p}{k} = \frac{p}{k} = \frac{p}{k} = \ldots\ldots$$

(iii) This may be extended to traction d.b.h.p. and fuel/traction d.b.h.p./hour as follows :
traction d.b.h.p. $\propto p \propto k$

$$\text{fuel/traction d.b.h.p. hour } \propto \frac{1}{p} \propto \frac{1}{k}.$$

(iv) When : $r_e = r_e C = W_e r_c = W_e r_e$,
$p = k\,(P + C) = k\,(P + W_e r_e)$
$= k \times$ rail t.e.

When : $r_e > r_c$,
$p = k\,[\text{rail t.e.} - W_e\,(r_e - r_c)]$.

Fig. 3. — Basic tractive effort relations.

of locomotive capacity and train resistance, enables time-tables to be planned so as to give greater margins between trains at junctions and other conflicting points, and so to give more liberal margins for recovery.

So far as locomotive power is concerned, the verifying of the basic tractive effort relations, by means of the controlled road system of testing, has been discussed many times previously in *The Engineer*; but for ready reference the diagram, figure 3, is included herewith, together with the accompanying " key ", taken direct from Mr. Ell's paper. The resistances of rolling stock quoted are of considerable interest, and comparison with values obtained from some of the older empirical formulae will indicate that a great deal has been done over the years to reduce the resistance of passenger stock. These values have been very thoroughly confirmed in many road tests.

Resistances of Current Passenger Stock.

Speed, m.p.h.	Resistance, pound per ton
10	3.65
20	4.53
30	5.67
40	7.01
50	8.58
60	10.33
70	12.30
80	14.52
90	17.07

It is significant of the changing times that when he comes to locomotive resistances Mr. Ell quotes figures only for non-steam types of locomotives. The total resistance on the level at any given speed V

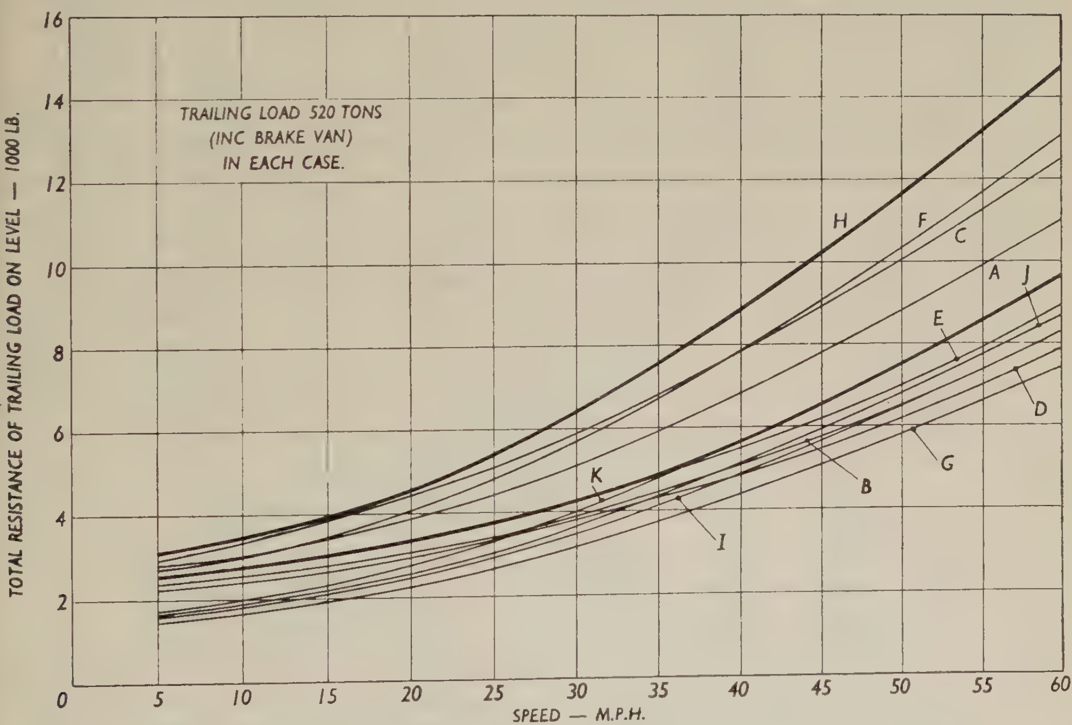


Fig. 4. — Resistance of freight vehicles.

is obtained from the basic tractive relations as shown in figure 3 :

$$R_e = P_r - \frac{p}{K} + W_e r_c$$

where :

P_r = rail tractive effort, pound;
R_e = total resistance of locomotive, pound;
p = actual tractive effort exerted on the trailing load, pound;
K = ratio of trailing load to gross weight of train;
W_e = weight of locomotive, tons;
r_c = resistance of trailing load, pound per ton.

The diagram, figure 2, shows the appropriate figures for four modern types of locomotive.

Data for multiple-unit stock follow, and in this case Mr. Ell considers that the total resistance of such trains on the level is best reckoned as made up of the sum of three quantities :

(*a*) Depending upon the weight of the train;

(*b*) Depending on the number of vehicles;

(*c*) A constant per train, being the same for a solo car as for a nine-car set.

The accompanying table gives a series of values that have been used in the planning of a large number of new timings, and which have proved reliable in service :

Resistances of Multiple-Unit Trains

Speed, m.p.h.	r_m	r_w	r_o
10	2.82	17.0	150
20	3.28	29.4	166
30	3.78	48.4	210
40	4.30	72.4	300
50	4.90	102.0	450
60	5.52	136.5	640
70	6.18	176.0	860
75	6.52	198.4	972

r_m = Factor depending on weight.
r_w = Factor depending on number of cars.
R_o = Constant.

To obtain the total resistances of a train at any speed the following formula is applied :

Total resistance = $Wr_m + Nr_w + R_0$ lb

where :

W = total weight of train, tons;
N = number of vehicles.

Freight vehicles constitute a much more complex problem, due to the variation in size, weight and shape of stock. Furthermore, the loading is to some extent unpredictable, and the planning of train schedules to the same degree of precision as with passenger trains is hardly a practical proposition. But because of the great need to improve freight train services, and the fact that the resistance of freight stock is in general considerably higher than that of passenger, weight for weight, a determined effort has been made to provide some data on which future planning can be based. Mr. Ell has derived the family of curves shown in figure 4 for a total train load of 520 tons, including brake van. These curves were obtained from road tests of a series of trains, all of the same total weight, but of different composition. For trains of similar composition and weight the total resistance can be taken as directly proportional to the weight. The graph references A to K on figure 4 relate to trains as follows :

Curve	Description	Weight/vehicle, tons	Class of traffic
A	Empty vans	7.9	—
B	Loaded vans	11.6	3
C	Empty vans	6.0	—
D	Loaded vans	13.0	2
E	Loaded vans	10.0	3
F	Empty wagons	7.5	—
G	Loaded wagons	23.5	1
H	Empty wagons	6.0	—
I	Loaded wagons	16.0	1
J	Loaded wagons	13.0	2
K	Loaded wagons	10.0	3

The envelope curves — shown in thick lines in the diagram figure 4 for both

empty and loaded wagons — give what might be termed as an overall result that could be used in general calculations. For a train of 520 tons of loaded vehicles the result is as follows :

Speed, m.p.h.	Total resistance, pound	Resistance, pound per ton
10	2 750	5.3
20	3 400	6.55
30	4 250	8.2
40	5 750	11.1
50	7 550	14.5
60	9 700	18.5

Comparing the above with those for current passenger stock in the table on page 723 it will be seen that at 60 m.p.h. the resistance is some 80 % greater, or equivalent to a passenger train of more than 950 tons. The figure above gives some insight into the power that will be needed for working the fast freight trains of the future.

Some examples of Mr. Ell's method of depicting engine performance in relation to the schedule required by the traffic department and to the cost of energy, as represented by the fuel consumption per ton-mile, have been published in *The Engineer* in connection with the tests carried out on the British Railways standard class " 8 " steam 4-6-2 locomotive No. 71000,

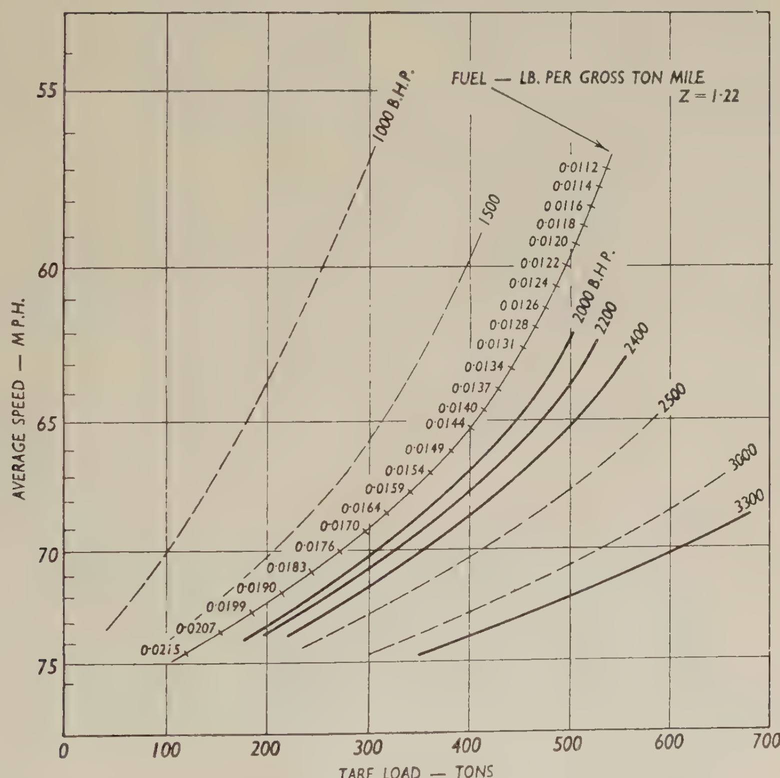


Fig. 5. — Performance and cost of energy computer. (Paddington depart to Newton Abbot, arrive non-stop 193.85 miles. Diesel locomotives : maximum speed, 90 m.p.h.)

Paddington	Westbourne Park	Southall	Slough	Maidenhead	Twyford	Reading	Newbury	Bedwyn	Savernake	Patney and Chirton	Lavington	Heywood Road Junction	Fairwood Junction	Clink Road Junction	Blatchbridge Junction	Castle Cary	Curry Rivel Junction	Taunton	Wellington	Whiteball	Tiverton Junction	Cullompton	Cowley Bridge Junction	Exeter St. Davids	Exeter St. Thomas	Exminster	Starcross	Dawlish Warren	Dawlish	Teignmouth	Newton Abbot	Total running time, minutes
4·2	10·2	9·9	5·8	7·0	5·6	20·7	16·9	5·8	11·5	4·9	6·7	2·2	3·6	2·3	13·4	14·7	11·3	8·5	8·4	4·9	1·9	10·0	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	216
4·2	10·1	9·8	5·7	7·0	5·5	20·5	16·6	5·7	11·4	4·9	6·6	2·2	3·5	2·2	13·3	14·6	11·2	8·4	8·2	4·9	1·9	10·0	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	214
4·2	10·0	9·6	5·7	6·9	5·4	20·4	16·3	5·6	11·2	4·8	6·5	2·2	3·5	2·2	13·3	14·6	11·1	8·3	7·9	4·8	1·9	10·0	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	212
4·2	9·9	9·5	5·7	6·8	5·3	20·2	16·1	5·4	11·1	4·8	6·4	2·2	3·4	2·2	13·2	14·5	11·0	8·2	7·7	4·8	1·9	9·9	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	210
4·2	9·8	9·4	5·6	6·7	5·2	20·1	15·9	5·3	11·0	4·7	6·4	2·1	3·4	2·1	13·1	14·4	10·9	8·2	7·4	4·8	1·8	9·9	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	208
4·2	9·7	9·3	5·5	6·7	5·1	19·9	15·6	5·2	10·8	4·6	6·3	2·0	3·4	2·1	13·1	14·3	10·9	8·1	7·2	4·7	1·8	9·9	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	206
4·2	9·5	9·2	5·5	6·6	5·0	19·8	15·4	5·1	10·7	4·6	6·2	2·0	3·3	2·0	13·0	14·2	10·8	8·0	7·0	4·7	1·8	9·8	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	204
4·2	9·4	9·1	5·4	6·5	4·9	19·7	15·1	5·0	10·5	4·6	6·1	2·0	3·3	2·0	12·9	14·1	10·7	7·9	6·7	4·7	1·8	9·8	1·5	1·0	3·7	3·9	2·4	2·0	4·3	6·8	202
4·2	9·3	9·0	5·3	6·5	4·8	19·5	14·9	4·9	10·4	4·5	6·1	1·9	3·2	2·0	12·9	14·0	10·5	7·8	6·5	4·7	1·8	9·8	1·5	1·0	3·6	3·9	2·4	2·0	4·3	6·8	200
4·2	9·2	8·8	5·3	6·4	4·8	19·4	14·6	4·8	10·3	4·5	6·0	1·9	3·1	1·9	12·8	13·9	10·4	7·7	6·3	4·6	1·8	9·8	1·5	1·0	3·6	3·9	2·4	2·0	4·3	6·8	198
4·2	9·1	8·7	5·2	6·3	4·7	19·2	14·4	4·7	10·2	4·4	6·0	1·9	3·1	1·9	12·6	13·8	10·3	7·5	6·2	4·6	1·8	9·7	1·5	1·0	3·6	3·9	2·4	2·0	4·3	6·8	196
4·2	8·9	8·7	5·2	6·2	4·6	19·0	14·2	4·7	10·0	4·4	5·9	1·9	3·0	1·9	12·5	13·7	10·1	7·4	6·0	4·6	1·7	9·7	1·5	1·0	3·6	3·9	2·4	2·0	4·3	6·8	194
4·2	8·8	8·5	5·1	6·2	4·5	18·9	14·0	4·6	9·9	4·3	5·9	1·9	2·9	1·8	12·4	13·6	10·0	7·3	5·8	4·6	1·7	9·6	1·5	1·0	3·6	3·9	2·4	2·0	4·3	6·8	192
4·2	8·7	8·4	5·0	6·1	4·4	18·7	13·8	4·5	9·8	4·3	5·7	1·9	2·9	1·8	12·3	13·5	9·9	7·2	5·6	4·6	1·7	9·6	1·5	1·0	3·5	3·9	2·4	2·0	4·3	6·8	190
4·2	8·5	8·3	5·0	6·0	4·4	18·6	13·5	4·4	9·6	4·3	5·7	1·9	2·9	1·8	12·1	13·3	9·8	7·1	5·4	4·5	1·7	9·6	1·5	1·0	3·5	3·9	2·4	2·0	4·3	6·8	188
4·2	8·4	8·2	4·9	5·9	4·3	18·4	13·3	4·4	9·5	4·2	5·7	1·8	2·9	1·8	12·0	13·2	9·6	6·9	5·3	4·5	1·7	9·5	1·5	1·0	3·5	3·9	2·4	2·0	4·3	6·8	186
4·2	8·3	8·0	4·8	5·9	4·2	18·2	13·1	4·3	9·4	4·2	5·6	1·8	2·8	1·8	11·9	13·1	9·5	6·8	5·1	4·4	1·7	9·5	1·5	1·0	3·5	3·9	2·4	2·0	4·3	6·8	184
4·2	8·1	7·9	4·8	5·8	4·2	18·1	12·9	4·2	9·3	4·1	5·6	1·8	2·8	1·8	11·7	12·9	9·4	6·7	4·9	4·4	1·7	9·4	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·8	182
4·2	8·0	7·8	4·7	5·7	4·2	17·9	12·7	4·2	9·2	4·1	5·5	1·8	2·7	1·7	11·6	12·8	9·2	6·5	4·8	4·3	1·7	9·4	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·8	180
4·2	7·9	7·7	4·6	5·6	4·2	17·7	12·6	4·2	9·0	4·0	5·5	1·7	2·7	1·7	11·4	12·6	9·1	6·4	4·6	4·3	1·6	9·4	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·8	178
4·2	7·7	7·5	4·5	5·6	4·1	17·5	12·4	4·1	8·9	4·0	5·5	1·7	2·7	1·7	11·2	12·5	9·0	6·2	4·5	4·3	1·6	9·3	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·8	176
4·2	7·6	7·4	4·5	5·4	4·1	17·4	12·2	4·1	8·8	4·0	5·4	1·7	2·6	1·6	11·1	12·3	8·9	6·1	4·3	4·2	1·6	9·3	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·7	174
4·2	7·5	7·2	4·4	5·4	4·1	17·2	12·0	4·0	8·7	4·0	5·3	1·7	2·6	1·6	10·9	12·1	8·8	5·9	4·2	4·2	1·6	9·2	1·5	1·0	3·4	3·9	2·4	2·0	4·3	6·7	172
4·2	7·3	7·1	4·3	5·3	4·0	17·0	11·9	4·0	8·5	4·0	5·3	1·7	2·5	1·6	10·8	12·0	8·6	5·8	4·1	4·1	1·6	9·2	1·5	1·0	3·4	3·8	2·4	2·0	4·3	6·7	170
4·2	7·1	7·0	4·2	5·2	4·0	16·8	11·7	4·0	8·4	3·9	5·3	1·6	2·5	1·6	10·6	11·9	8·5	5·7	3·9	4·1	1·6	9·1	1·5	1·0	3·4	3·8	2·4	2·0	4·3	6·7	168
4·2	7·0	6·8	4·2	5·1	4·0	16·6	11·6	4·0	8·3	3·9	5·3	1·6	2·5	1·5	10·4	11·6	8·4	5·5	3·8	4·0	1·6	9·0	1·5	1·0	3·4	3·8	2·4	2·0	4·3	6·7	166
4·2	6·8	6·7	4·1	5·0	3·9	16·4	11·5	3·9	8·2	3·9	5·3	1·6	2·4	1·5	10·3	11·5	8·3	5·4	3·6	4·0	1·5	9·0	1·5	1·0	3·3	3·8	2·4	2·0	4·3	6·7	164
4·2	6·7	6·5	4·0	4·9	3·9	16·2	11·3	3·9	8·1	3·9	5·2	1·6	2·4	1·5	10·1	11·3	8·2	5·3	3·5	3·9	1·5	9·0	1·5	1·0	3·2	3·8	2·4	2·0	4·3	6·7	162
4·2	6·5	6·4	3·9	4·8	3·9	16·0	11·2	3·9	8·0	3·9	5·2	1·5	2·4	1·5	9·9	11·1	8·1	5·1	3·4	3·8	1·5	8·9	1·5	1·0	3·2	3·8	2·4	2·0	4·3	6·7	160
4·2	6·3	6·2	3·8	4·7	3·9	15·8	11·1	3·9	7·9	3·8	5·2	1·5	2·3	1·5	9·8	10·9	8·1	5·0	3·3	3·7	1·5	8·8	1·5	1·0	3·1	3·8	2·4	2·0	4·3	6·7	158
4·2	6·1	6·2	3·8	4·6	3·8	15·5	11·1	3·8	7·8	3·8	5·2	1·5	2·3	1·5	9·6	10·8	8·0	4·8	3·2	3·6	1·5	8·7	1·5	1·0	3·0	3·8	2·4	2·0	4·3	6·6	156

A margin for random contingencies must be allowed in accordance with the text.

Basic schedules maximum power, point-to-point times-minutes.

in August, 1957; the principles involved have now been applied to the production of " performance and cost of energy computers ", and an example is shown herewith in figure 5 relating to a diesel-hydraulic 2 000 d.b.h.p. locomotive on the West of England main line of the Western Region. The basic of the computer is the performance of the locomotive at full power wherever possible, subject only to permanent speed restrictions, due to curves, etc., to the maximum speed permitted with the particular class of traffic, and to the available brake power. The performance is technically determinable for a variety of loads. Into the basic schedule the margin for contingencies, such as temporary permanent way restrictions, signal checks and such like is inserted, and the final practical schedule may contain also localised adjustments for minor traffic disturbances, but they are not included in the data presented by the computer, because, like station stopping time, they do not depend on technical factors.

A remarkable verification of data presented by the computer came in the course of a run on the 4.10 p.m. express from Plymouth to Paddington on July 16, 1958. The load was 448 tons tare, and the locomotive a diesel-hydraulic of the 2 200 b.h.p. type, No. D.800. Due to severe delays on the western part of the journey the train left Taunton well behind time, and the full power of the locomotive was used to recover as much time as possible. The road was clear throughout, so that, with correct observation of all speed restrictions, the conditions were ideal for checking the predicted times of the computer. The train covered the 143 miles from Taunton to Paddington in 128 min., at a start-to-stop average speed of 67 m.p.h. — and this overall time differed only by 12 sec. from that given by the computer for these conditions.

Clearly computers of this kind can provide a most valuable tool for the planning and establishment of schedules for entirely novel forms of motive power, and their use on an increasing scale should help greatly towards the achievement of increased productivity, not only with the new forms of motive power, but also with steam. For some years to come steam will be the mainstay of British railway motive power, and yet there is a strong desire to improve services wherever possible. The intelligent use of computers such as those devised by Mr. Ell, in conjunction with accurate performance data from the various test bulletins, should prevent anomalies in loading, or scheduling the existence of which, if persisting, can only lead to bad timekeeping, or the wasteful expedient of double heading.

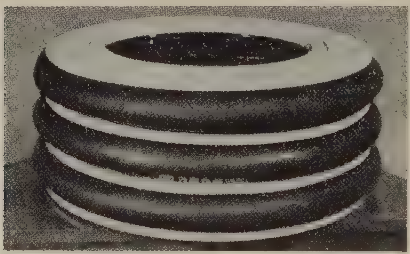
[625 .213 (52)]

Pneumatic springs for Japanese rolling stock.

Test results with J.N.R. passenger stock and comparison with coil spring bogies.

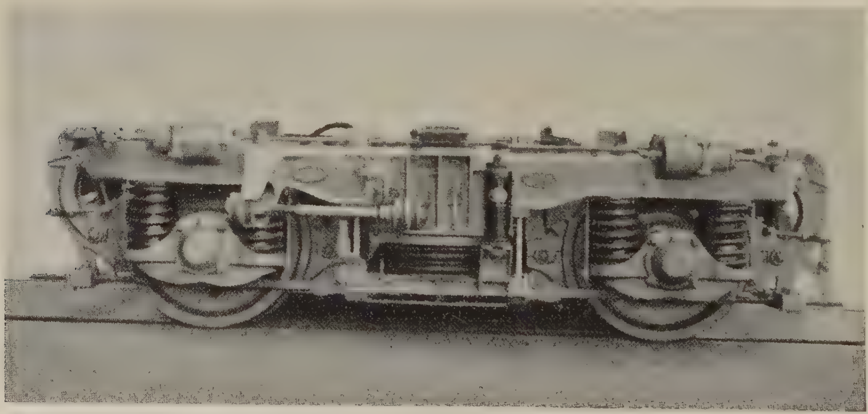
(*The Railway Gazette*, February 13, 1959.)

Pneumatic springs have been developed rapidly in Japan over the last three years mainly due to the serious overcrowding experienced in suburban passenger trains in large cities such as Tokyo and Osaka. The loading of a car can vary from zero to 22 t during the peak period. In general the highest and lowest heights of the couplers of Japanese rolling stock are 2 ft. 11 in. and 2 ft. 7 $^1/_8$ in. respectively. The difference between the two limits is 3 $^5/_{16}$ in., therefore the maximum deflection of the bearing springs is limited to as little as $^5/_{32}$ in. or less per ton of load per car. The deflection is very low compared with good riding stock in Europe and the U. S. A., where a deflection of $^7/_{32}$ in. to $^5/_{16}$ in. per ton of load per car is permitted.



Pneumatic-spring bellows for the KS-51 bogie. The diameter is 22 in.

A pneumatic spring supports a car body by inflating rubber bellows with compressed air. The pressure can be varied automatically, according to the variation in the load, by a height-control valve, so that the floor height can be kept constant.



KS-51 bogie, showing the pneumatic spring fitted to the bogie bolster, and coil springs on the journal boxes.

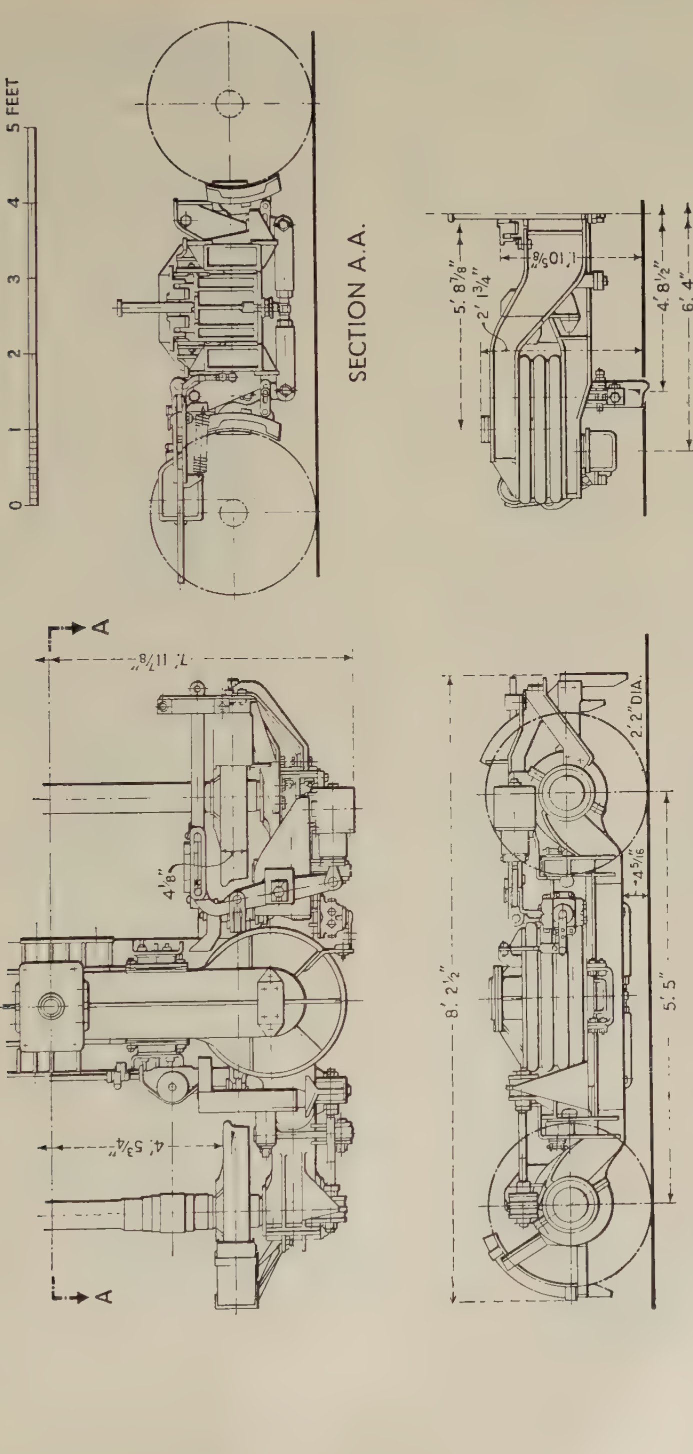
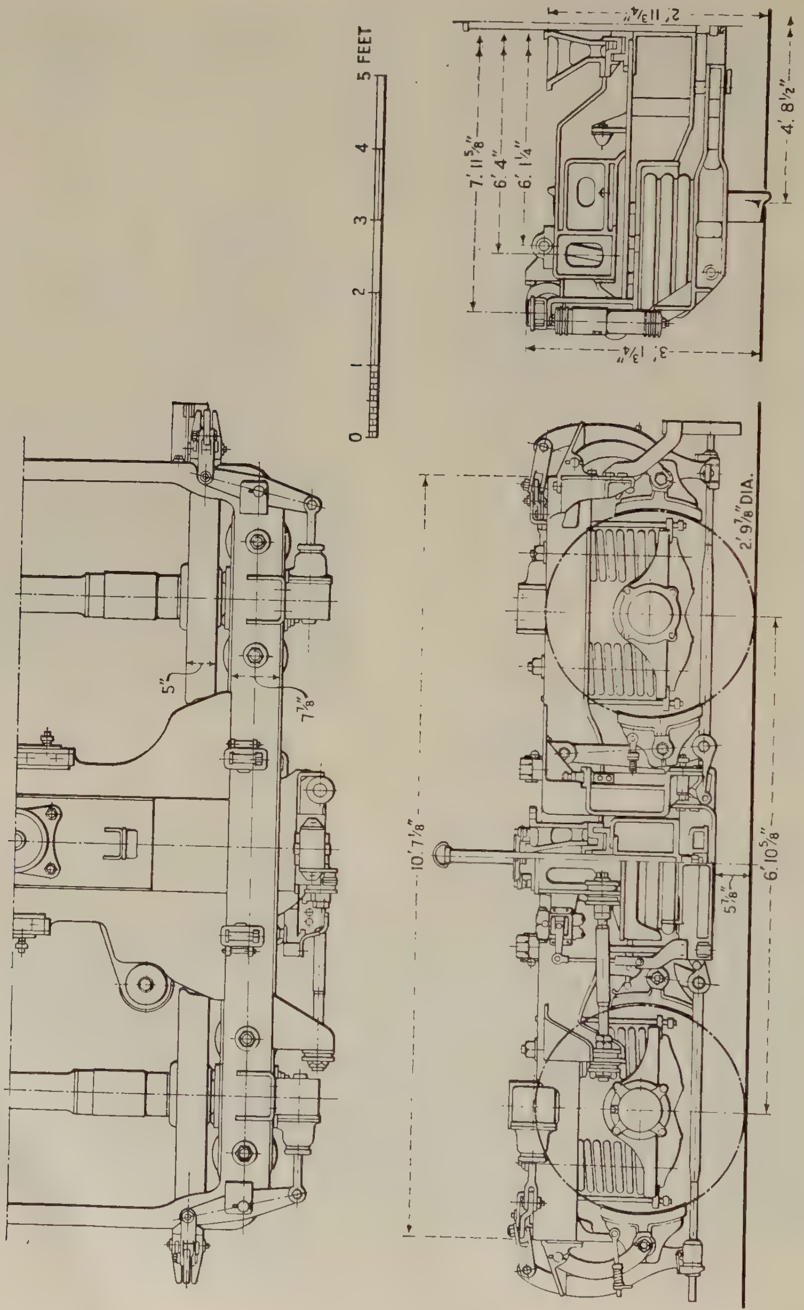


Diagram of the KS-53 bogie designed for the Nankai Electric Railway, showing general arrangement and principal dimensions.



Elevation and plan of KS-51 bogie. This is the Kisha Seizo Kaisha standard design of bogie with pneumatic springs.

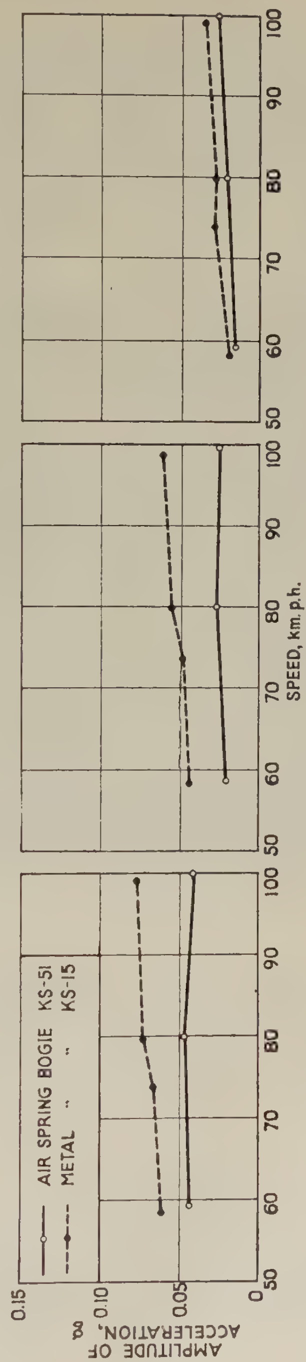
Test run.

The first test run with stock equipped with air springs was carried out on the Tohoku Line near Tokyo in March, 1956. The air springs were manufactured by Kisha Seizo Kaisha and fitted temporarily on a Diesel railcar. After satisfactory test results the Keihan Electric Railway decided to install these springs on its multiple-unit trains for the limited express service between Kyoto and Osaka. The first car so fitted was put in service in June, 1956, and this was followed by a further nine.

The National Railways have also made wide use of air spring bogies, and some 100 vehicles have been equipped including the stock for the multiple-unit electric train « Kodama » operating an express service between Tokyo and Osaka, and the « Asakaze » train-de-luxe operating as a limited express between Tokyo and Hakata. The « Kodama » was described and illustrated in our issue of December 19, 1958. When air springs were originally installed on the bogies of the Keihan Electric Railway they were fitted to the journal boxes. It was found, however, that sufficient height could not be obtained when the bellows were inflated because of the inclination of the bogie frame. The difficulty was overcome by fitting the pneumatic spring and its control valve on the bogie bolster.

KS-53 design.

Kisha Seizo Kaisha Limited has also designed the air-spring bogies fitted to the newly-built street cars of the Nankai Electric Railway, Osaka. The diameter of the wheels is 2 ft. 2 in., and the wheel base is 5 ft. 5 in. By using the lateral flexibility of the air-spring bellows, the swing hangers of the bogie were eliminated. The tare weight of the car is 16 t and the output of the motors, four to each car, is 40 HP. The general arrangement of the bogie, designated KS-53, is shown in the diagram on page 729.



Longitudinal vibration.

Lateral vibration.

Vertical vibration.

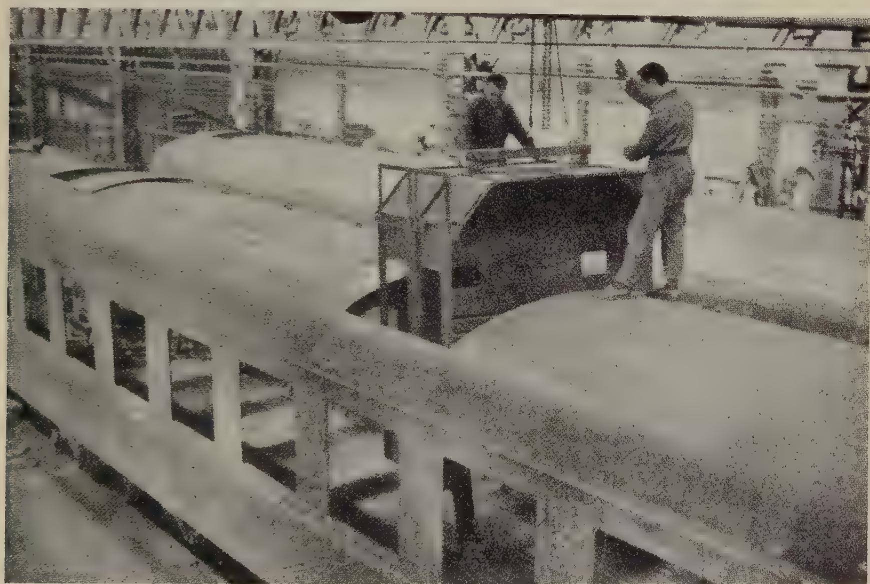
Tests carried out with a multiple-unit train fitted with Kisha Seizo Kaisha KS-51 air-spring bogies on the National Railways confirmed good riding qualities on the 3-ft. 6-in. gauge track at speeds up to 135 km.p.h. (84 m.p.h.). The increase in the frequency of vibration in the centre plate of the bogie was measured and compared with that of a KS-15 bogie with coil springs and oil dampers. The comparison in represented in the accompanying diagrams. In the KS-51 air-spring bogie the increase in the frequency of vertical vibration was less than 30 to 40 % and in lateral vibration less than 50 to 60 % mean value of the KS-15 coil-spring bogie. The mean maximum deflection in the air spring bellows while in motion was in the region of $\pm$ $^5/_{16}$ in. The normal diameter and height of the bellows is 1 ft. 9 $^5/_8$ in. and 7 $^5/_{16}$ in. respectively, and the maximum working pressure is 5 kg. per sq. cm .(71 lb. per sq. in.). During tests the maximum variation in pressure was about $\pm$ 0.2 kg. per sq. cm. (2.8 lb. per sq. in.). The bellows are made of oil-proof rubber and two-ply nylon tyre fabric.

[625 .26 (44)]

Simplified passenger coach construction.

Use by French builders of prefabricated compartment units to ensure quicker repair and cheaper maintenance.

(*The Railway Gazette*, January 9,1959.)



Lowering prefabricated half-compartment through roof aperture.

With the encouragement of the French National Railways, certain French manufacturers of railway rolling stock have been studying simplification of design and materials without deterioration of standards. The problem is stated to have been aggravated by difficulties in obtaining orders partly because French standards, and, therefore, prices seemed higher than necessary.

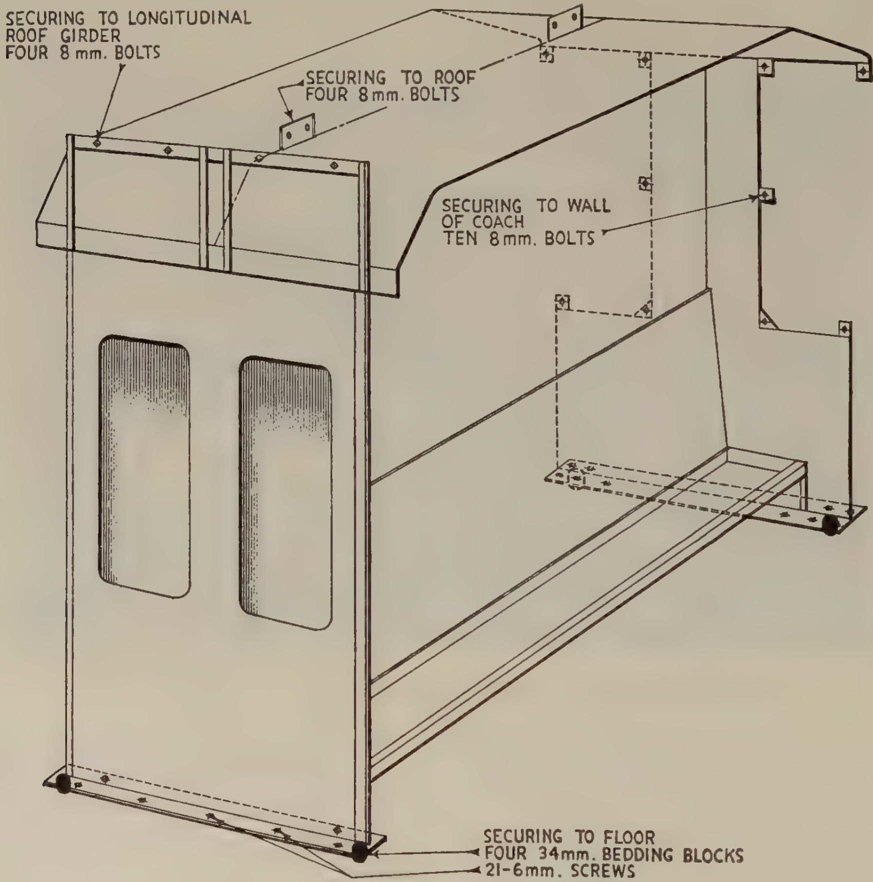
The Ateliers de Construction du Nord de la France (A. N. F.), in co-operation with the S. N. C. F., recently built, and exhibited at Paris Saint-Lazare terminus, the prototype of an « economic coach ». The aim in designing this, a 10-compartment, side-corridor, second class vehicle was to reduce the capital cost, and to ensure quicker repair and cheaper maintenance.

Prefabrication.

Departing from the orthodox coach construction methods, whereby a metal body is first constructed and subsequently equipped with partitions, seats, lighting, heating, and other fitments, A.N.F. decided

to make as much use as possible of prefabrication. The body was designed to facilitate introduction of prefabricated sections through a trap-door opening in the roof. This opening extends over the full width of the coach roof and occupies the space between two curved metal roof

To obviate the possibility of a weak point, the roof around the opening was reinforced. In addition, a metal framework is bolted into place, on which the removable roof section is secured. To ensure that the roof remains watertight, the joint is sealed with neoprene.

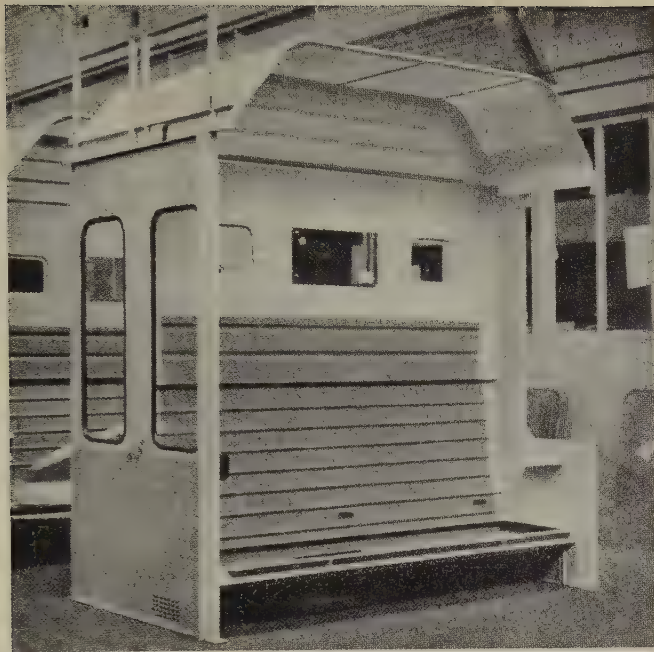


Method of securing prefabricated units to ceiling, floor and side wall of coach.

members. These latter replace the more usual tympan metal plate system of roof construction, both to facilitate the provision of an opening and to facilitate the securing of the prefabricated units.

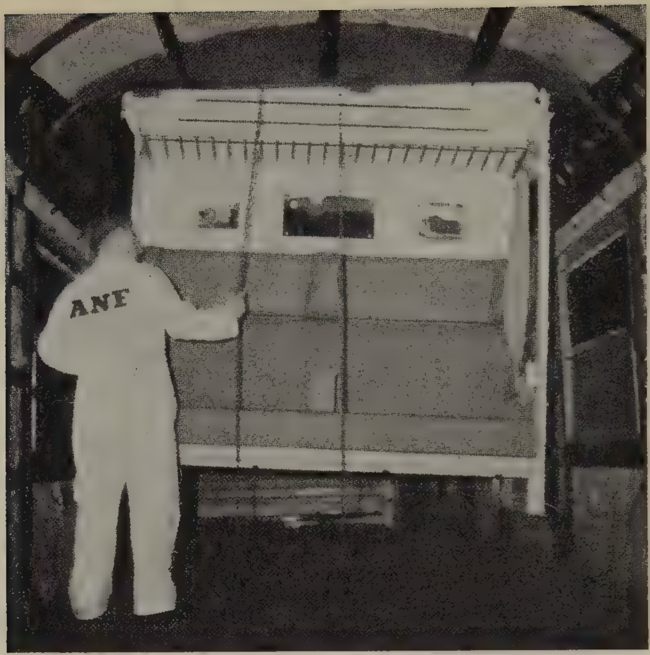
Half-compartments.

The prefabricated units consist mainly of two half-compartments, back-to-back, to form parts of adjacent compartments.



Complete painted half-compartment before lowering into body of coach.

Roof opening through which prefabricated units are lowered. Note reinforcement.



After lowering and before moving along floor to final position in coach.

Roof opening before affixing sheeting, showing welded roof members.

They include the transversal and side bulkheads, entirely of metal construction, on which are fixed ceiling, seats, and luggage racks, all of which can be carried out on the continuous assembly principle. Considerable use is made of welding. Before being installed in the coach body, the units are fully equipped with furnishings and fittings, and are painted. Certain wall, as shown in the accompanying diagram. The manufacturers claim not only that construction costs are much lower than by more orthodox methods, but that sections can be easily removed by the same process for repair or replacement.

The decision to prefabricate sections consisting of half-compartments back-to-back, rather than complete compartments,

End of corridor, showing articulated ceiling section. False cornice for electrical circuits and door mounting on left.

units are made up of a half-compartment and toilet compartment, the latter equipped with a wash basin and w.c.

After units have been lowered through the roof opening into the coach body, they are moved along the floor of the coach to their final positions where they are bolted to the floor, roof, and coach

was taken as the resulting units were smaller, there being no need to take into account the space between the seats, whilst the prefabrication work itself was easier.

There was no departure from the normal S.N.C.F. standards in respect of the bogies and the outside walls of the coach body. The only way in which the external

appearance of the prototype differed from that of other modern S.N.C.F. coaching stock was the roof opening.

New interior features.

Internally, a considerable number of differences are apparent. A simple type of false cornice has been installed along the ceiling above the entrance vestibule and along the corridor, that on the compartment side providing readily accessible space for electrical circuits, alarm circuits and for the mounting of the sliding compartment doors, thus simplifying maintenance. The ceiling of the corridor is composed of painted corrugated steel sections. These are articulated to give easy access to the electrical circuits, etc. Certain windows, particularly those on the corridor side of the compartments and those of the toilet compartments, are mounted in rubber frames, similar to the practice of the motor-car industry.

Use of materials.

Because of their high cost, little use has been made of laminated products. This has been largely replaced in the compartments and toilets by sheet steel coated with special hard-gloss self-drying paint, the condition of which will be closely watched as there is a risk that the initial saving might be offset by higher maintenance cost. Some use has been made of plastics, particularly in the toilet compartments. Thus w.c. cisterns and pipes are made of special types of laminated polyesters and polyvinyls respectively. In the toilet section, which is divided by a partition from the w.c., the water inlet fitting to the wash basin and a shelf above the basin are made of stainless steel as are the picture frames in the passenger compartments. For the luggage racks a light aluminium/steel alloy has been used. Other innovations in the compartments include push-button control fluorescent lighting and curtains instead of blinds.

[656 .235 (492)]

The goods rates policy of the Netherlands Railways,

by Dr. A. Parent, Utrecht.

(*Internationales Archiv für Verkehrswesen*, No. 1, January, 1958.)

The policy governing the fixing of goods rates is at present the subject of a good deal of study, and even of debates in various international assemblies. It is therefore interesting to examine, in some detail, the rather special position which the Netherlands Railways have been able to take up since 1934, as there is an obvious interest in studying the results of an administrative practice where a discrimination is made between different clients and where goods rates are fixed by agreement. This is the subject of the noteworthy article published by Dr. A. Parent in « Internationales Archiv für Verkehrswesen » of January 1958, which we can, unfortunately, only produce in part.

Departing from the general objective laid down by Parliament for the transport policy of the Netherlands, namely to create and maintain a reasonable and permanent transport service, the author recalls that, in other forms of transport, such as most of the services on roads and waterways, it is hardly possible rigidly to adhere to a policy where the goods rates are published and applicable to all. Therefore, if economic efficiency is to be ensured in all circumstances, it is necessary to base the price of each transport on the cost price and on the market conditions; in other words, the prices must be freely determined. As a matter of fact, experience in many countries has shown that, for these categories of transport undertakings, it is not possible to enforce respect for obligatory goods tariffs. In the Netherlands, the goods rates on the roads were, at first, left entirely free. Then, during the war, maximum rates were laid down. On the waterways, both maximum and minimum limits were fixed.

In view of these competitive conditions, the Dutch railways legislation was amended, as from 1934, so that the Netherlands Railways, too, were able to conclude individual agreements with clients and were merely required to observe maximum limits. The policy of the Netherlands Railways whose prime objective it is to ensure the survival of the undertaking in the long run has induced them constantly to modernize their apparatus from the technical point of view. Although the railways were working at a loss in 1939, they have made a slight profit since the war, in spite of the fact that the goods rates index has only risen to 222, whilst the wholsesale price index and the cost of living index have risen to 380 and 294, respectively.

This paradox is explained partly by the general modernisation, which is a permanent pre-occupation of the leading officials, and partly by the goods rates policy. But to maintain an appropriate degree of economic efficiency (seeing that the policy of a public undertaking cannot be wholly governed by profit-making considerations) is a difficult matter where the external conditions are continually changing.

The author continues with these words:

But let us revert to the question of special non-published rates agreements. The maximum rates are limited by the published tariffs. The level at which the agreed rates are fixed depends on the cost price and on the market conditions. There is nothing new in that : industry at large does precisely the same inasmuch as prices

are based on cost price and on market conditions. The price is worked out by an estimates section of the financial department where a considerable amount of data is available so that the necessary estimates can very quickly be made available to the commercial department. Knowledge of the true cost price is a matter of the greatest importance, notably where the transports call for a special organisation (e.g. shuttle trains or unscheduled marshalling operations).

The situation of the market and the transport requirements are studied by the market research section of the commercial department where the development of traffic is analyzed and the market of certain commodities is regularly investigated. To a great extent, such limited market investigations are supported by the commercial organisation for passenger and goods traffic which comprises the twelve agencies in the major cities of the Netherlands as well as certain agencies abroad, viz. those in Germany, Belgium, France and Switzerland. These agencies explore the conditions within their own areas and keep in close and constant contact with the clientele. They are the feelers which keep the management informed about the wishes and complaints of the clientele. They are assisted in their work by a number of headquarters specialists, e.g. for container traffic, palletized traffic, traffic at lump-sum prices, refrigerated traffic.

Nowadays, only a comparatively small fraction of all the *wagon load traffic* on the Netherlands Railways is still carried at normal rates. As far as inland traffic is concerned, the bulk of the traffic must be carried at agreed rates, in competition with waterways and road transport. The actual conditions are thus often very complicated. As far as prices are concerned, consignors will base their choice of itinerary and means of transport not only on the transport rates proper but on the total costs to be borne for the transport from door to door. In other words, as far as railway transport is concerned, the price is made up by the railway goods rates and the collection and delivery costs. As it happens, the collection and delivery costs vary considerably according to circumstances. A great number of factors play a part : availability of private sidings; location of consignors and consignees in relation to the railway station, port or waterway; transhipment facilities, etc. It is obvious that, if such important elements of the total price are apt to vary individually, the correct competitive rates must, in their turn, also be determined individually. The great advantage of the tariff agreements concluded by the Netherlands Railways with the consignors or consignees, as the case may be, lies in the very fact that they are individual, and that they can be more closely adapted to a given competitive position than, e.g., a special tariff of general validity. This is rather like the advantage of tailor-made clothing compared with ready-made clothing with this difference that, in our case, the tailor-made clothing is cheaper to the customer into the bargain. Generally, the rates agreements specify a minimum quantity of goods to be handled, a condition which, as one knows, is also often imposed in special tariffs of general validity.

In part-load traffic, the lump-sum contract system has become very widespread. At present, about half of the part-load traffic is carried on this basis. In certain respects, the tariff for less-than-wagon load consignments in force on the Netherlands Railways differs from the tariff adopted by other European railway administrations. The most important differences are these :

(1) In collaboration with a number of transport undertakings (notably « Van Gend & Loos », who are also concerned with goods collection and delivery services), who run regular van routes for « smalls » traffic from centre-stations, it is possible to ensure the direct transport of smalls, even between a great number of localities which have no railway station.

The country is thus covered by a close-mesh transport system, and transports are

carried out from end to end at the normal smalls tariff of the Netherlands Railways.

(2) The goods tariff is determined not only by the weight of the consignment and the distance but also, to a not insignificant extent, by the volume of the goods. Up to 1st April, 1957, smalls were charged for at least 200 kg per cubic metre. Since 1st April, 1957, the charge has been based on 300 kg per cubic metre. This is a system which has been used for a long time by the shipping companies and which makes it necessary not only to weigh the goods but also to measure them when they are accepted for conveyance.

(3) The rates for smalls include the cost of delivery to the consignee's address.

Under their lump-sum price system, the Netherlands Railways conclude an agreement whereby the railways undertake to carry all the inland smalls traffic of a consignor at an average price (at lump-sum rate) per 100 kg. For this purpose, the consignor must authorize the Netherlands Railways beforehand to carry out an analysis of all his consignments, and must undertake to send all his smalls exclusively by railway and under the conditions of the agreement. In practice, these agreements are only concluded with large firms, generally industrial undertakings, and the railway administration carries out regular checks whether the conditions on which the lump-sum price agreement was based are still applicable.

For the consignor, the advantage of this agreement does not lie so much in the transport price itself. It is his personal position in relation to the competition which may or may not enable him to benefit from a reduction. The great advantage to the consignor lies in the administrative and technical simplicity of the system which enables him, for example, to make out in a single operation the waybill (of a special, much simplified type), the address label, the dispatch advice, the invoice, and to benefit from a simplified invoicing system, generally on a monthly basis, for the transport charges without having to check each single consignment. Such a procedure can obviously only be offered and sucessfully carried out by a transport undertaking which, like the railway, is able to provide a ubiquitous or at least widely ramified service.

[625 .251]

Temperature increase in railway wheels caused by braking,

by Stig Anvill, Surahammars Bruks AB, Surahammar, Sweden.

(Järnvägsteknik-Statsbaneingenjören, No. 6A, 1958.)

During the spring of 1955 the laboratory of Surahammars Bruks AB had the opportunity, in cooperation with the Swedish State Railways and the Central Laboratory of ASEA, to undertake some measurements of the temperature increases in railway wheels caused by braking. The tests were carried out on the ore line between Kiruna and Narvik. Holes for thermocouples were drilled in two wheels, one of the solid wheel type and one of the assembled wheel type (fig. 1), and the cold junctions of the thermocouples were placed on the axles. The wheel sets were used on ore wagons with an axle load of 18 t. Each wagon had three axles, two of which were braked. The thermocouple e.m.f.s. were transmitted via sliprings, manufactured by ASEA [1], to the dynamometer car of the Swedish State Railways, where they were recorded by two Leeds & Northrup Speedomax recorders. The wagons and the dynamometer car were coupled to ordinary ore trains. The temperature of the thermocouple T-1 about 7 mm beneath the thread was recorded continuously, and the temperatures of the other thermocouples were read about every third minute when the train was passing interesting sections of the line. The dynamometer car was

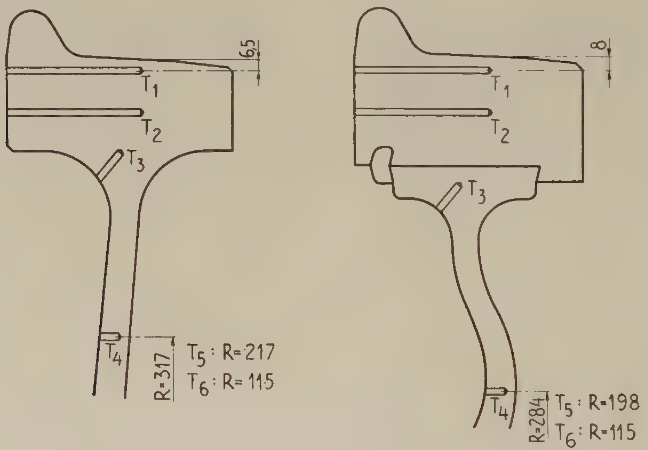


Fig. 1. — Location of thermocouples in the wheels.

(1) K.R. Meldahl : « Dynamic Forces on Railway Wheel Sets », Bulletin of the International Railway Congress Association. Vol. 30 (1953) : 6, p. 303-329.

equipped with a recording speedometer. The braking was generally made with a direct air pressure brake, and the air pressure in the brake pipe was measured by a pressure gauge placed between the test wagons and the dynamometer car. Resistance strain gauges were used to measure the axle strains in the test wagons, using a technique described by MELDAHL (1).

On the Swedish side of the line the most difficult gradient is situated between Bergfors and Torneträsk, with an altitude difference of about 90 m in 10 km, where maximum temperature differences between T-1 and the axle of 92° for the solid wheel and 100° for the assembled wheel were recorded. The gradient between Riksgränsen (Swedish-Norwegian border) and Narvik is considerably steeper, with an altitude difference of 460 m in 35 km (1.3 % average incline), and the temperatures recorded were higher: 170° for the solid wheel and 190° for the assembled wheel. Figure 2 shows the temperature distribution in the solid wheel between Riksgränsen and Narvik.

On one of these runs the brake shoes of the solid wheel set failed to release, and after about 45 min a temperature difference of 255° between T-1 and the axle was recorded. Figure 3 shows the temperature conditions during this brak-

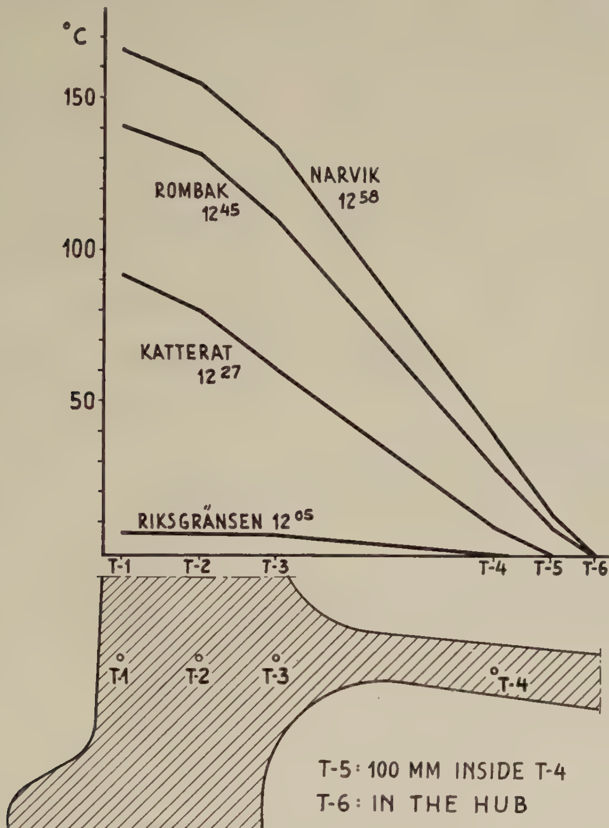


Fig. 2. — Temperature distribution in the solid wheel.

ing. The braking force per wheel was estimated at about 2 200 kg.

Figure 2 shows that the heat produced by braking is transmitted to the surrounding air. In consequence there is no noteworthy temperature rise in the wheel disk. The hub is not influenced at all.

For the ore wagons used the braking force per wheel is about :

$$P = 1\,000 \; . \; a,$$

Only a part of this energy is transmitted to the wheel. The rest is transmitted to the brake shoes.

To simplify, assume the quantity of heat conducted in each second from the tyre to be proportional to the temperature difference T between tyre and axle. We then obtain :

$$T = \frac{W}{c}\left(1 - e^{-\frac{c}{K} \cdot t}\right)$$

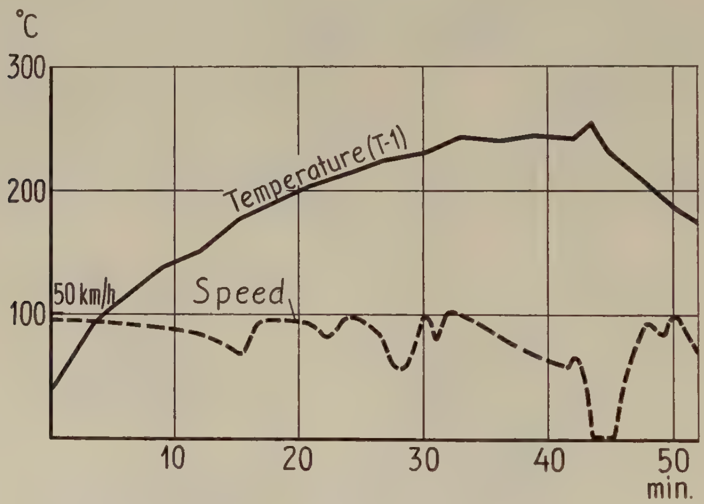


Fig. 3. — Temperature and speed curves for accidental braking.

where a is the air pressure in the brake pipe. At 40 km/h the friction coefficient between the brake shoe and the tyre is about 0.11. The weight of the wagon (54 t) is distributed on four braked wheels, and in order to keep a constant speed (v) a retarding force of 175 kg per wheel is consequently required on a 1.3 % incline. This gives a braking force of 1 600 kg, corresponding to 1.6 kg/cm² in the brake pipe. Values between 1.0 and 1.8 kg/cm² were observed on the pressure gauge.

The energy produced by braking is :

$$W_1 = P \; . \; \eta \; . \; v \text{ kgm/sec.}$$

K is the heat capacity of the tyre (for this type about 20 kcal per degree). The other constants in the above equation have been calculated from the temperature-time curves obtained during the trial runs between Riksgränsen and Narvik :

$W = 0$ kcal/sec. (at 0 km/h);

$W = 3.0$ kcal/sec. (at 40 km/h and P = 1 600 kg per wheel);

$c = 0.006$ kcal per sec. and degree (at 0 km/h);

$c = 0.018$ kcal per sec. and degree (at 40 km/h).

As a total average, the braking produced about 4.2 kcal per sec for each wheel (= W), and about 70 % of this has been transmitted to the wheel (W/W_1). From the wheel further heat is transmitted to the surrounding air (depending on the speed), so that for instance in Narvik only 23 % of the total braking energy was stored in the wheel as heat energy.

At severe brake shoe applications of short duration a larger proportion of the braking energy remains in the wheel, but it can naturally never exceed 100 %. The kinetic energy per wheel of a 45 t express train coach is tabulated below, with the corresponding average tyre temperature, assuming that all braking energy is stored in the tyre :

Speed km/h	Kinetic energy kilocalories per wheel	Tyre temperature
70	575	30°
90	900	45°
120	1 600	80°

Consequently the average temperature of the tyre after stopping a train from high speed with high brake shoe pressures is relatively low. In the thread, however, the temperature increase is considerable, with a steep temperature gradient, which can cause thermal cracks. Repeated severe brakings cause high tyre temperatures.

On another test run with a passenger train on the line Stockholm-Malmö-Gothenburg-Stockholm the observed temperatures were low during normal traffic. Between Malmö and Ängelholm, however, with traffic of more local type and frequent stops, the temperatures were considerably higher (about 70° at the thermocouple T-1 about 7 mm beneath the thread). A « drag test » with braking at a speed of about 90 km/h gave a temperature increase of 205°.

One intention in these tests was to find out whether the temperature differences in the wheel due to braking were high enough to cause serious mechanical stresses in the wheel plates. The observed temperatures were of the same magnitude as the shrinking temperatures used in assembling tyres and centres, that is well below the yield point, and as the braking stresses must be considered to be static stresses they seem to be fairly harmless. Even with added maximum dynamic stresses the yield point of the material — about 42 kg/mm² — is not exceeded. An extrapolation of the results observed in these tests to higher speeds and brake pressures shows, however, that tyre temperatures of 600° and more may be possible, for instance when the brake shoes fail to release after a severe application. In that case severe damage can be caused to the wheels.

NEW BOOKS AND PUBLICATIONS.

[**625** .28 (45)]

DIEGOLI (M.). — **Storia del Mostro** (Le nostre locomotive a vapore *(Our steam locomotive)*.— A pamphlet (4 3/8 × 8 1/4 in.) of 96 pages with numerous illustrations and coloured plates. — No. 10 of the Collection « Quaderni delle Ferrovie Italiane dello Stato », on sale from bookshops and the Railway Museum at Roma Termini. (Price : 350 lires).

Supplanted by more modern engines, the steam locomotive is dying out, but as in the first days of its invention, it still excites the admiration of technicians, not only on account of the harmonious arrangement of its components, but also because of the extraordinary impetus it gave to industry. Stationary engine or locomotive, its history is linked up with that of human progress over more than a century and consequently well deserves study.

In the work which he has dedicated to the steam locomotive, M. Diegoli reviews the history of its development in Italy.

After briefly recalling the principles on which it functions and mentioning the first tentative steps of its heroic period, the author makes us follow, step by step, the stages in the perfecting of the locomotive, which as far back as 1872 developed original characteristics in Italy. Amongst these stages, mention may be made in particular of the introduction of double expansion, the designing of the motor-carrying bogie, and the application of superheating.

The first world war, whilst testing the excellent quality of the rolling stock of the Italian Railway, which stood up to a stringent test, nevertheless put a brake on technical progress.

After hostilities ceased, this was recommenced and extended and several new types of locomotives were put into service. From this period also dates the development of the poppet valve distribution.

However, electrification and dieselization of the railway developed and with the designing of the type 691 *Pacific* locomotives in 1929 the activities of the Research Dept. of the Italian State Railways came to an end.

From that time, it has merely dealt with improvements, and very successful ones, to existing locomotives.

Very pleasant to read, M. Diegoli's book is an invaluable document in studying a particularly lively period of railway technique.

R. S.

[**313** : **656** (497)]

Schweizerische Verkehrsstatistik *(Swiss Transport Statistics)*, 1957. — One volume (8 1/4 × 11 1/2 in.) of 162 pages and 6 additional graphs. — 1958, Berne, published by the *Federal Transport Office*. (Price : 12 Swiss francs.)

The « Swiss Transport Statistics, 1957 », which the *Federal Transport Office* has just published gives for this year, as it has done in the past, very complete statistics concerning the activities of all the Swiss transport undertakings.

An analysis of this document makes it clear that the transport section has profited by the very favourable economic situation which was maintained during 1957, although during the last few months of the year, the traffic transported was lower

than in the corresponding months of the previous year. In general, the receipts increased, but nonetheless not to the same extent as the costs.

The Federal Railways, whose operating coefficient is 70.6 %, recorded in 1957 an increase in traffic, both passenger and freight, which increase was due to a large extent to traffic in transit.

The private railways also, on the whole, recorded an increase in traffic, but road competition had an unfavourable effect upon much of this. The overall operating coefficient is slightly above 87.5 %.

The special types of railway, which are now in full swing, have followed the development of tourist traffic. In ten years, the transport capacity of these undertakings has increased fivefold, and the number of telpher railways put into service is constantly on the increase.

The report also gives detailed information concerning the position of road traffic as well as the navigation services on the lakes and rivers. It ends with a chapter devoted to air transport.

In sum, this publication owing to the data it supplies, forms a document of first class value for any economic study in connection with transport.

R. S.

[**656** .25]

SIGNAL UND DRAHT, Jubiläumsaugabe zum 50 jährigen Bestehen *(50th anniversary of the Review « SIGNAL UND DRAHT »)*. — Special number (Nov.-Dec. 1958 of the review) with 78 pages (8 1/4 × 11 3/4 in.), copiously illustrated. — 1958, Frankfurt-am-Main, Dr. A. TETZLAPF-Verlag, Niddastrasse, 64. (Price : 6.— DM.)

The very interesting review « Signal und Draht », one of the very few publications specially devoted to railway signalling and telecommunications, has just celebrated its fiftieth anniversary by publishing a double number (November/December 1958) devoted to future prospects together with a brief historical review.

The first name of the review « Das Stellwerk » was abandoned when publication was resumed in 1947 in order to stress by the new name adopted the double field to be dealt with in the future. Although the review « Signal und Draht » is mainly devoted to German technique, which is strengthened by its semi-official nature, it frequently publishes studies by authors from other countries. The articles are always of a high standard, being more concerned with explaining the principles and guiding ideas rather than the details of actual realisations not in common use and the description of installations which are not really typical.

Tendencies in the development of signalling and telecommunications on the Deutsche Bundesbahn are described by Professor SCHMITZ in the first article of this special issue. As regards signalling, it will be noted that a great many steps have been taken to simplify and standardize the methods of planning new installations. The developments briefly described in the case of telecommunications are concerned, in conjunction with extensions of the telephone installations, with more numerous applications of radio, telegraphy, various special loudspeaker equipments, and finally the introduction of electronic equipment to sort information and data.

Dr. H. SASSE and M. H. GRUBER have each written an article devoted to the present evolution of signalling and telecommunications on the German railways.

In the following article, M. K. F. KÜMMELL gives in detail the principles involved in drawing out itineraries automatically according to the train running diagrams, which supply both information concerning

the approach of trains and their destination. Different cases of possible conflict between itineraries are analysed, and the solutions given. A description is also given of a concrete application.

M. W. LEITENBERGER deals with the electronic installation dealing with train reservations. The equipment, which is already being used with success on the ferries between Germany and Denmark, can be consulted through the telegraph system by any station. The train reservations are stored by a magnetic drum on which the telegraphical impulses also work when a reservation is made from a distance. The article ends with a description of the studies in hand for new developments.

It will be seen therefore that this special issue is mainly devoted to the future and to new developments.

P. SCH.

[385 (09 (3)]

World Railways 1958-1959. A worldwide Survey of Railway Operation and Equipment. — Fifth edition. — Collected and published by Henry SAMPSON. — A bound volume (8 3/4 × 13 in.) of 358 pages with numerous maps and illustrations. — 1959, London W. 1. Sampson Low's « World Railways » Ltd., 25, Gilbert Street. (Price : £ 5.5.0 *d.*)

The fifth edition of this important work, based on the same general plan as the previous editions, describes the situation of the railways of the world in 1957.

In an extremely lucid foreword, the author stresses the special difficulties with which the railways are faced, in competition with all the other methods of transport.

He also stresses the universal tendency towards the progressive elimination of steam traction in favour of more modern kinds of traction, as well as the improvements made to operating methods, mechanisation of marshalling yards, centralised traffic control, door to door services either by containers or « Piggy-back ».

The first part of the work is devoted to information about the railways.

General information about all the railway Administrations is grouped into tables by continent and in alphabetical order.

Moreover, all the main railways are the subject of more detailed articles, which give for the years 1956 and 1957, the financial results, the evolution of the use of the different methods of traction, electrification schemes undertaken, modifications made to the rolling stock, the main work on the permanent way, the signalling and station equipment.

The second part deals with the activities of rolling stock manufacturers. Each heading is illustrated by photographs showing the most striking productions of these firms during the years in question.

The book ends with a few notes dealing with the mechanisation of marshalling yards, centralised traffic control, and the design of the Swedish ultra-light KLL trains.

To sum up, this volume, with its copious illustrations and numerous maps, gives a complete picture of the railways of the whole world.

R. S.

[656 .25]

Lexikon der Hochfrequenz-, Nachrichten- und Elektrotechnik. — Band 3 *(Dictionary for high frequency, telecommunications and industrial electricity techniques. — Volume 3).* — A bound volume with a flexible binding of imitation leather, 876 pages (4 3/4 × 6 1/2 in.), with numerous diagrams and graphs. — Publisher Curt RINT. Editors : Verlag Technik, Berlin and Porta Verlag KG, München. (Price : 28.75 DM.)

The third volume of this dictionary follows the traditions of the two previous volumes.

It covers the definitions in the German language beginning with the letters from K to Q (inclusive) and relates not only to the techniques included in the title but also to their interconnected sciences.

Each of the terms is followed by its translation into English, French and Russian, and is the subject of an explanatory note. Where necessary, a drawing or diagram of the principle completes the explanation, and the author frequently gives bibliographical references.

This third volume covers terms relating to such different subjects as cables, klystrons and everything to do with nuclear energy, information concerning dipoles, the technique of light and the propagation of radio-electric waves, magnetism, mesons (particles of the intermediate mass between the positron and proton).

The ideas which come into play in modulation, the motors, multiband circuits and multivibrators are carefully dealt with, as are the other techniques: polarization, theory of quantics, etc.

During the last few years, science has made enormous progress, especially in the electrical field.

The techniques of both heavy and ultra-light currents have undergone such a striking development, that only specialists in each branch can follow it.

More and more frequently, industrial applications however are calling upon both the classic forms of electricity.

Mr. C. RINT's dictionary will then prove an extremely useful work of reference.

The electronician will find therein the basic information concerning the machine or equipment with whose protection or automatization he is concerned. The specialist in heavy currents will find a definition of the notions of electronics with which he may not be familiar.

This dictionary therefore seems to us to constitute an invaluable addition which it will be essential to include in any research library.

F. B.

[656 .28 (42)]

Brigadier C.A. LANGLEY, Chief Inspecting Officer of Railways, Ministry of Transport and Civil Aviation. — **Report to the Minister of Transport and Civil Aviation upon the Accidents which occurred on the Railways of Great Britain during the year 1957.** — A pamphlet (6 × 9 7/8 in.) of 72 pages and graphs. — 1958. Her Majesty's Stationery Office, York House, Kinsgway, London W.C. 2 and 423, Oxford Street, London W. 1. (Price : 4/- *s.* net.)

The report drawn up by Brigadier C. A. LANGLEY upon the accidents which occurred on the railways of Great Britain during the year 1957 follows the same plan as the reports for previous years.

The accidents are grouped into three categories :

— train accidents (derailments, collisions) and damage to rolling stock and the permanent way;

— traffic accidents (in connection with the train services);

— other accidents (having no connection with the train services).

In his general review of the position in 1957 compared with 1956, the author reports that there was a slight reduction in the number of train accidents recorded (1 205 compared with 1 226) as well as a more substantial reduction (1 679 compared with 2 009) in damage to rolling stock and permanent way. The number of victims unfortunately increased : 1 074 (112 killed and 962 injured) compared with 608 (18 killed and 590 injured) in 1956. The people killed were 92 passengers, 4 railway employees and 16 other persons, 15 of them occupants of road vehicles involved in collisions at level crossings.

Traffic accidents increased from 4 741 (49 killed and 4 692 injured) to 4 778 (46 killed and 4 732 injured). As in previuos years, the passengers themselves were chiefly to blame for these accidents : getting into and out of moving trains, falls, opening and shuntting doors without due care. As far as the staff were concerned, the number of victims also slightly increased (2 243, i.e. 147 killed and 2 096 injured compared with 2 110, i.e. 144 killed and 1 966 injured in 1956), but remains lower than the average for the period 1951-55 (2 368).

Other accidents caused the deaths of 31 persons, 25 of them railway employees, compared with 28 and 24 respectively in 1956.

The author then goes on to examine in detail the accidents in the first category. Of the 1 205 accidents which occurred in 1957, 621, i.e. 51.5 %, were directly due to human error, whilst 128, i.e. 10.7 % were the result of technical defects, also attributable to human error. Going on to review the 11 accidents which resulted in an official enquiry, amongst which was the terrible collision at St. Johns, Lewisham, which cost the lives of 90 persons, the author stresses that 4 of these, in particular the Lewisham accident, could have been avoided by the use of automatic train control equipment. In each case, he indicates the steps which have been taken to remedy human errors and improve the installations and stock.

In the following chapters of his report, devoted to a study of the second and third categories of accidents, the author deals at length in particular with the accidents which occurred to railway employees, as well as those occurring at level crossings.

In a special chapter : « Review of the year », the author then returns to and analyses one by one the primary causes of accidents. In particular, he is glad of the reduction in the number of accidents due to mistakes by the signalmen, but on the other hand, draws attention to the greater number of accidents, more than 18 % of the average for 1951-1955 due to mistakes on the part of the train staff and engine crews. Although amongst these latter accidents, the number of times signals have been run past at danger has fallen by 40 % compared with the 1951-55 period, this same fault was the cause of 5 very serious accidents. The extension of automatic train control installations would lead to an appreciable improvement in this matter. A special campaign to educate the staff has also been initiated.

The author is also concerned at the accidents occurring at level crossings and announces that several measures are being studied to improve the safety at these danger points.

Finally, the author stresses the increase (more than 10 % compared with the previous year) of serious accidents to employees. This situation is all the more disappointing as the British Transport Commission and trades unions have devoted a great deal of attention to the question of improving the safety of employees; consequently, the author asks all those concerned to redouble their efforts in order to reduce the number of such accidents.

R. S.

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